Geol Survey

CHARLESTON AREA

Geological Science Field Trip

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Department of Energy and Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
Champaign, IL 61820

A GUIDE TO THE GEOLOGY OF THE CHARLESTON AREA

By

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THE GEOLOGIC FRAMEWORK

Geologic history of the Charleston area. The Charleston field trip in southeastern central Illinois lies in an area that was repeatedly covered by great continental glaciers during the geologically recent Ice Age (Pleistocene Epoch). The first glaciers may have covered this area some 700,000 years ago (Kansan time); the last ice sheet melted from the northern part of the field trip area nearly 20,000 years ago (Wisconsinan time). Wind-blown silt, called loess (pronounced "luss"), of late Wisconsinan age blankets the poorly sorted till or ground moraine (often called drift), left behind by the various glaciers. Generally, loess thickness ranges from about 2 to 6 feet, but locally, near some of the streams, erosion has removed all but a few inches. The productive soils covering much of Illinois have developed slowly in the loess over thousands of years.

The northern part of the field trip area is along a part of the series of ridges of Wisconsinan-age glacial deposits called the Shelbyville Morainic System. This morainic system marks the southern boundary of the Bloomington Ridged Plain (fig. 1). This plain is generally characterized by low, broad ridges (moraines) separated by wide stretches of relatively flat or gently undulating land. Although the larger Wisconsinan moraines are conspicuous from a distance, they are less obvious near at hand because of their gentle outer slopes. The minor moraines, on the other hand, tend to be prominent locally. Glacial deposits are fairly thick throughout the Bloomington Ridged Plain and generally conceal the bedrock surface, except locally. In the Charleston area, glacial deposits exceed 200 feet in thickness near the crest of the outermost of the Shelbyville Moraines.

Below the Wisconsinan deposits are older drifts (Illinoian and Kansan) over which the Wisconsinan glaciers advanced. South and about 100 to 120 feet lower in elevation than the crest of the Shelbyville Morainic System, is the Springfield Plain (fig. 1), which includes the level area of the sheet of Illinoian glacial drift in this part of our state. Although the Springfield Plain generally is flat with tabular uplands, locally its surface is gently undulating and has modern drainage shallowly entrenched in it. Even though glacial deposits are thinner here than in the Wisconsinan moraines to the north, surface topography is essentially the result of glacial deposition and subsequent erosion by streams. The drift is generally less than 25 feet thick beneath the tabular uplands, but exceeds 100 feet in the buried bedrock valleys.

Illinoian glaciers covered the state several times from perhaps 300,000 to 175,0000 years ago. During Illinoian time, North American continental glaciers reached their southernmost extent, advancing from Canada as far as the northern part of Johnson County in southern Illinois. These Illinoian glaciers built morainic ridges similar to those of the Wisconsinan, but apparently not so numerous. In addition, these Illinoian moraines have been subjected to weathering and erosion for thousands of years longer and thus, generally, are not as conspicuous as the Wisconsinan moraines. Scattered across the Springfield Plain are a number of low, conical-shaped hills called "kames", which are interpreted to be mounds of gravel that were deposited by melt-water from the glaciers. These landforms built by the Illinoian glaciers have been eroded and weathered and then mantled by Wisconsinan loess (for more

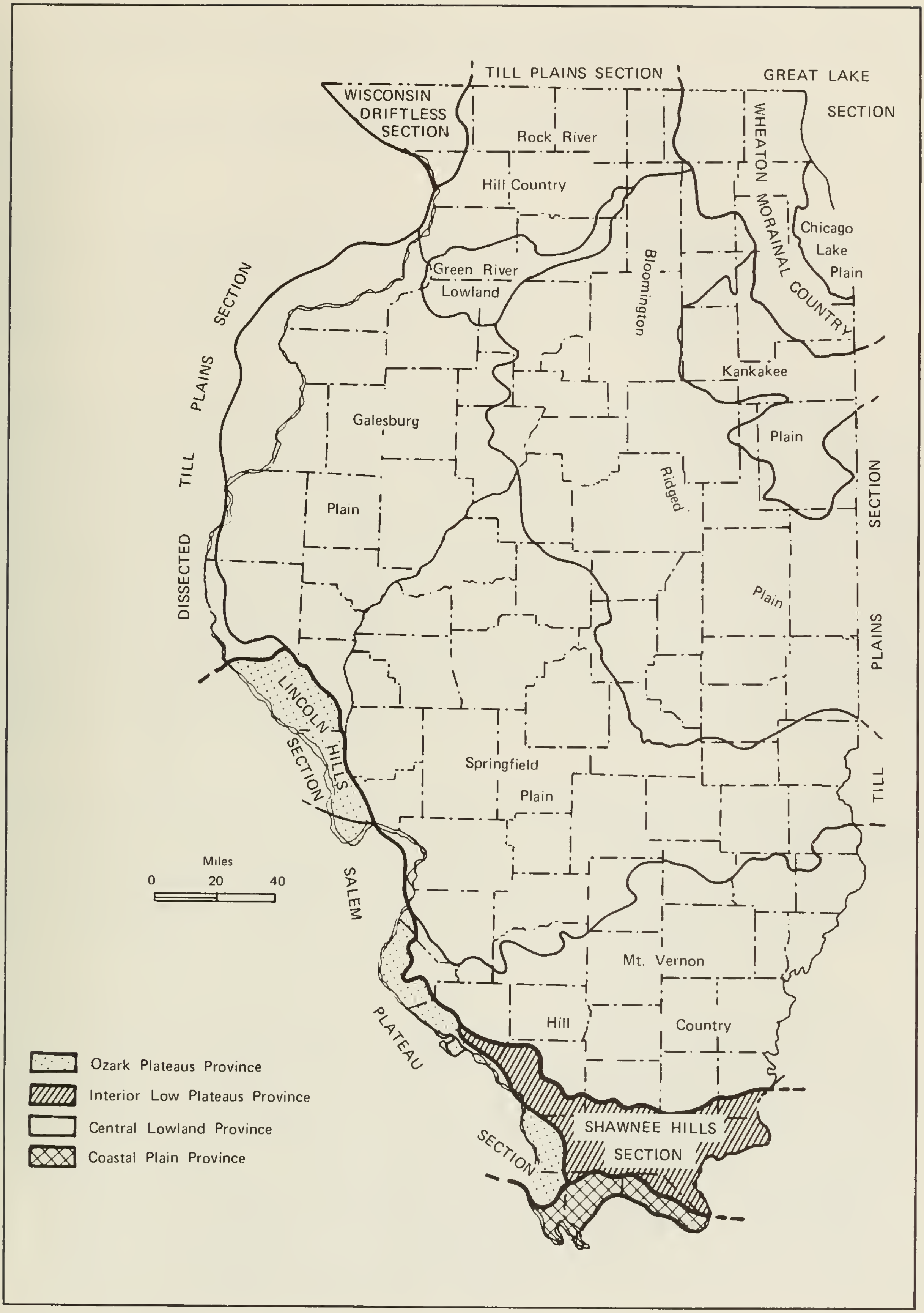


Figure 1. Physiographic divisions of Illinois.

details concerning glaciers see the attached blue pages, "Pleistocene Glaciations in Illinois," at the back of the guide leaflet).

Surface water in the field trip area drains westward to the Embarras (pronounced "Ambraw") River principally via Polecat, Whetstone, Opposum, Hurricane, and Clear Creeks. The Embarras River flows south and eastward into the Wabash River.

The highest surface elevation on the Charleston field trip itinerary is at the intersection (490N; 2100E) on the S-curve of the Westfield Road (mileage 16.75+). The elevation is about 761 feet above mean sea level (m.s.l.). The lowest elevation on the field trip, at Clear Creek (mileage 42.7+), is slightly less than 561 feet (m.s.l.). The overall surface relief along the field trip route, then, is approximately 200 feet.

The bedrock below the glacial deposits was formed from ancient sediments deposited layer upon layer in shallow seas and swamps that repeatedly covered the Midcontinent region millions of years ago. Sediments forming the youngest known bedrock strata in this area were deposited during the Pennsylvanian Period, some 285 million years ago. These strata contain Illinois' valuable coal resources and are often referred to as the "Coal Measures." In the field trip area, the Pennsylvanian rocks range in thickness from about 450 feet in the northeast to about 750 feet in the southwest. An unknown thickness of younger Pennsylvanian and perhaps even younger Permian strata may have been deposited above the rocks now found here. However, all traces of these younger strata apparently have been removed by weathering and erosion during the 225 million years or so that elapsed between their deposition and the slow advance of the glaciers across the area. Details concerning the Pennsylvanian sedimentary rocks are included in the attached gray pages, "Depositional History of the Pennsylvanian Rocks".

A number of bedrock exposures noted by early workers and residents in the Charleston field trip area are no longer easily found. This is largely the result of man's influence on his environment. For instance, as farming became more mechanized during the last 40 years or so, trees and the sod cover on the hillsides were removed to gain more tillable acres. As a result, the hillsides eroded much more readily and many of this area's streams became choked with silty sediments. Thus, bedrock strata formerly exposed along valley walls are now buried beneath modern sediments washed from the uplands.

Deep oil wells in nearby areas have penetrated strata of the Mississippian, Devonian, Silurian, and Ordovician systems (fig. 2). The deepest well, more than 3,400 feet, bottomed in the Ordovician St. Peter Sandstone Formation in the Martinsville Oil Field. Elsewhere in Illinois, deep wells have penetrated several thousand feet of sandstone, siltstone, shale, limestone, and dolomite that occur between the Ordovician rocks and the much more ancient crystalline rocks called Precambrian. Nearly 8,000 feet of sedimentary rock occur above the Precambrian here. In Illinois, the surface of the Precambrian basement consists mainly of granite and rhyolite that give radiometric ages ranging from 640 million to nearly 1.4 billion years ago. Granite and other Precambrian igneous and metamorphic rocks occur at the surface around the upper Great Lakes and in Canada, and pieces of them have been carried into the field trip area by the glaciers during the Ice Age.

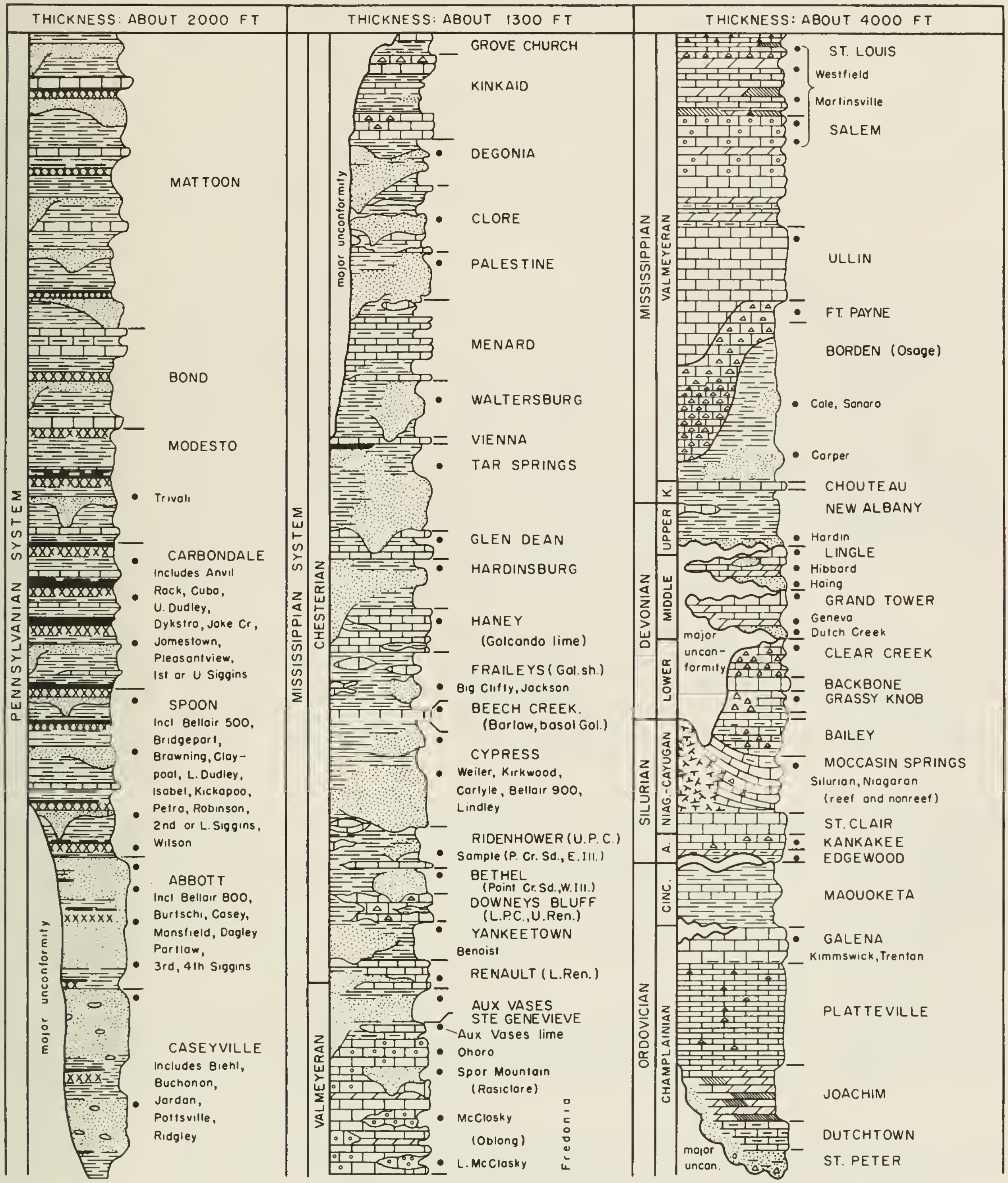


Figure 2. Generalized geologic column of southern Illinois. Black dots indicate oil and gas pay zones. Formation names are in capitals; other pay zones are not. About 4,000 feet of lower Ordovician and upper Cambrian rocks under the St. Peter are not shown. The names of the Kinderhookian, Niagaran, Alexandrian, and Cincinnatian Series are abbreviated as K., Niag., A., and Cinc., respectively. Variable vertical scale. (Originally prepared by David H. Swann.)

After the Precambrian basement rocks were formed, they were eroded to make a landscape probably similar to parts of the present-day Missouri Ozarks. Beginning some 525 million years ago, the hilly Precambrian landscape began to slowly sink and thus permitted the invasion of a shallow sea from the south and southwest. During the millions of years of the Paleozoic Era, southern Illinois continued to receive sediments and sink until at least 15,000 feet of sedimentary rocks accumulated there (figs. 3 and 4). There were times during the millions of years of deposition during the Paleozoic Era, however, when the seas withdrew and the deposits were subjected to weathering and erosion. As a result, there are some breaks in the sedimentary record in Illinois.

Near the close of Mississippian time, gentle arching of the rocks in eastern Illinois initiated the development of the La Salle Anticlinal Belt (fig. 3). Further arching slowly continued through Pennsylvanian time. Because of the absence of the youngest Pennsylvanian strata from the area of the anticlinal belt, we cannot know just when movement along the belt ceased--perhaps by the end of the Pennsylvanian or maybe later, near the close of the Paleozoic Era. The La Salle Anticlinal Belt is a complex structure throughout its extent; in the field trip region many smaller structures, such as domes, anticlines, and synclines, are superimposed on it. Some of these smaller structures have oil fields associated with them in strata of Pennsylvanian, Mississippian, Devonian, and Ordovician age at depths to well below 2,000 feet. In general, the bedrock strata dip southwestward away from the crest of the La Salle Anticlinal Belt and toward the deeper parts of the Illinois Basin.

Following the Paleozoic Era, during the Mesozoic Era, the Pascola Arch (fig. 3) rose in southeastern Missouri and western Tennessee to structurally separate the Illinois Basin from other basins to the south. Development of this arch in conjunction with the post-Pennsylvanian sinking of the deeper part of the Illinois Basin, gave the Illinois Basin its present spoon-shaped configuration.

Mineral production. Of the 102 counties in Illinois, 99 reported mineral production during 1984, the last year for which complete records are available. The total value of all minerals mined was about $3.1 billion. Coles County ranks 40th among all counties on the basis of the total value of its production of crude oil, natural gas, stone, and sand and gravel. Cumberland County ranks 43rd on the basis of its production of crude oil and sand and gravel.

More than 42.7 million tons of stone valued at more than $166.8 million were produced from 169 operations in 54 Illinois counties. Two quarries owned and operated by the same company produced stone in Coles County. Production and value figures are withheld to protect individual company data. There were no stone producers in Cumberland County.

Sixty-one Illinois counties produced nearly 26 million tons of sand and gravel valued at almost $72.5 million from 190 operations. Two companies operate 3 pits in Coles County. Production and value figures are withheld to protect individual company data. Three operations in Cumberland County produced more than 200,000 tons of sand and gravel having a value of more than $440,000. Cumberland County ranks 16th among the counties releasing production data.

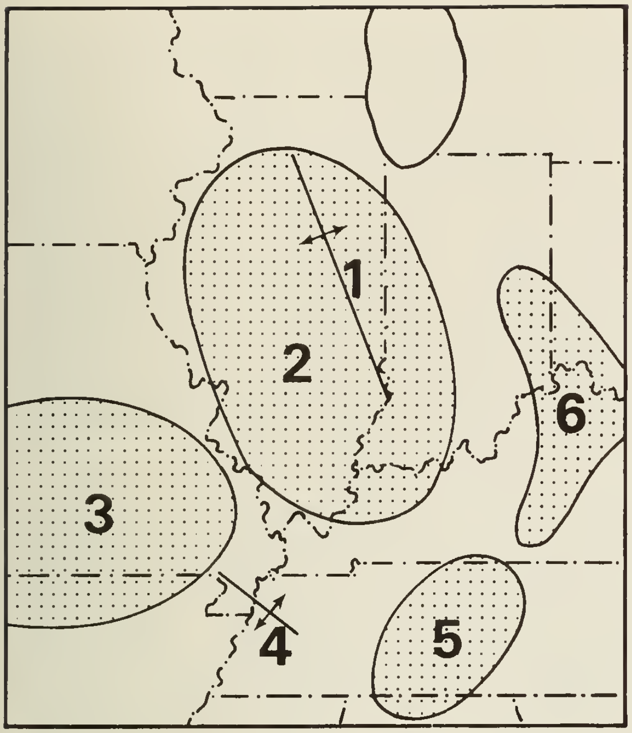


Figure 3. The location of some of the major structures in the Illinois region: (1) La Salle Anticlinal Belt, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, and (6) Cincinnati Arch.

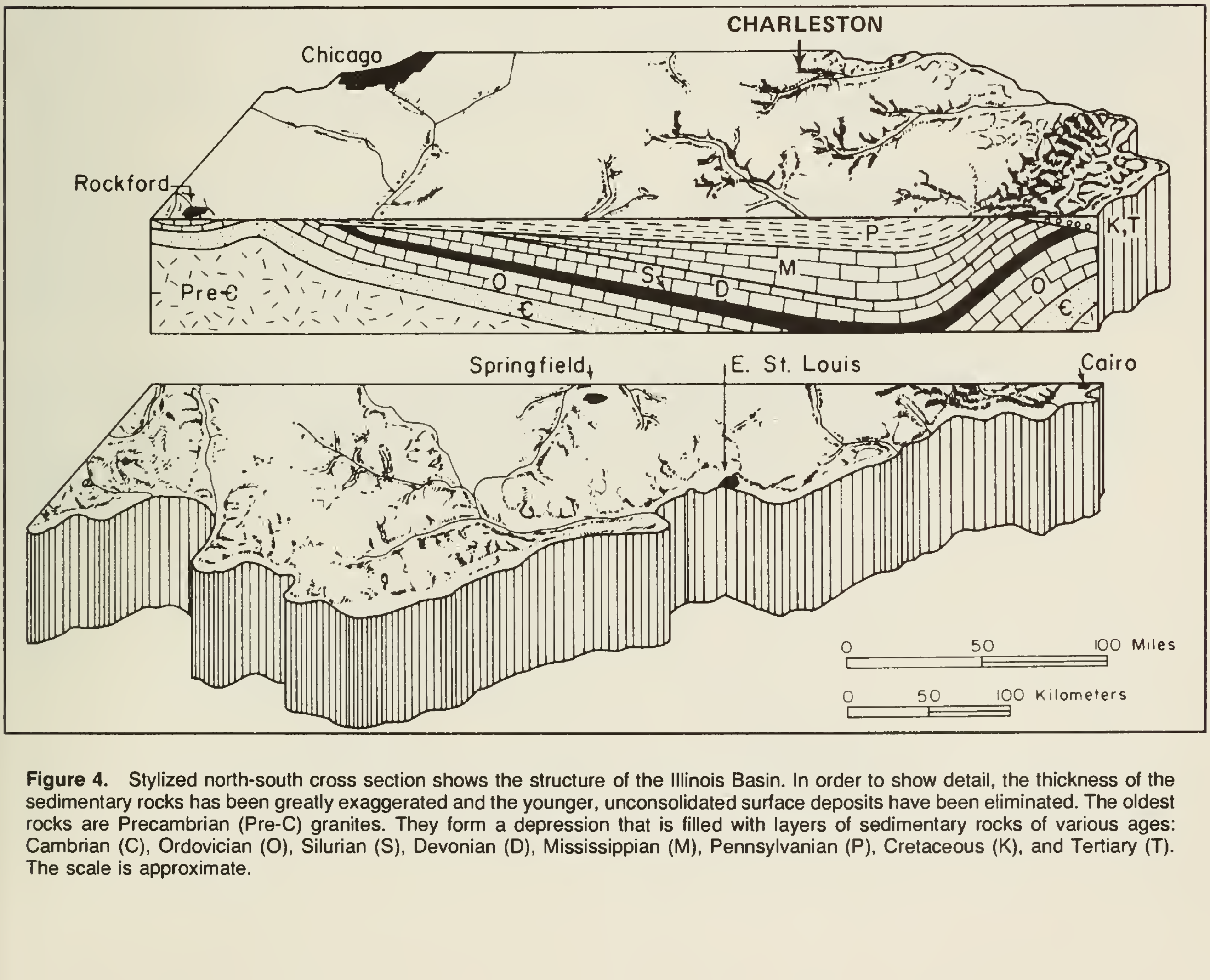


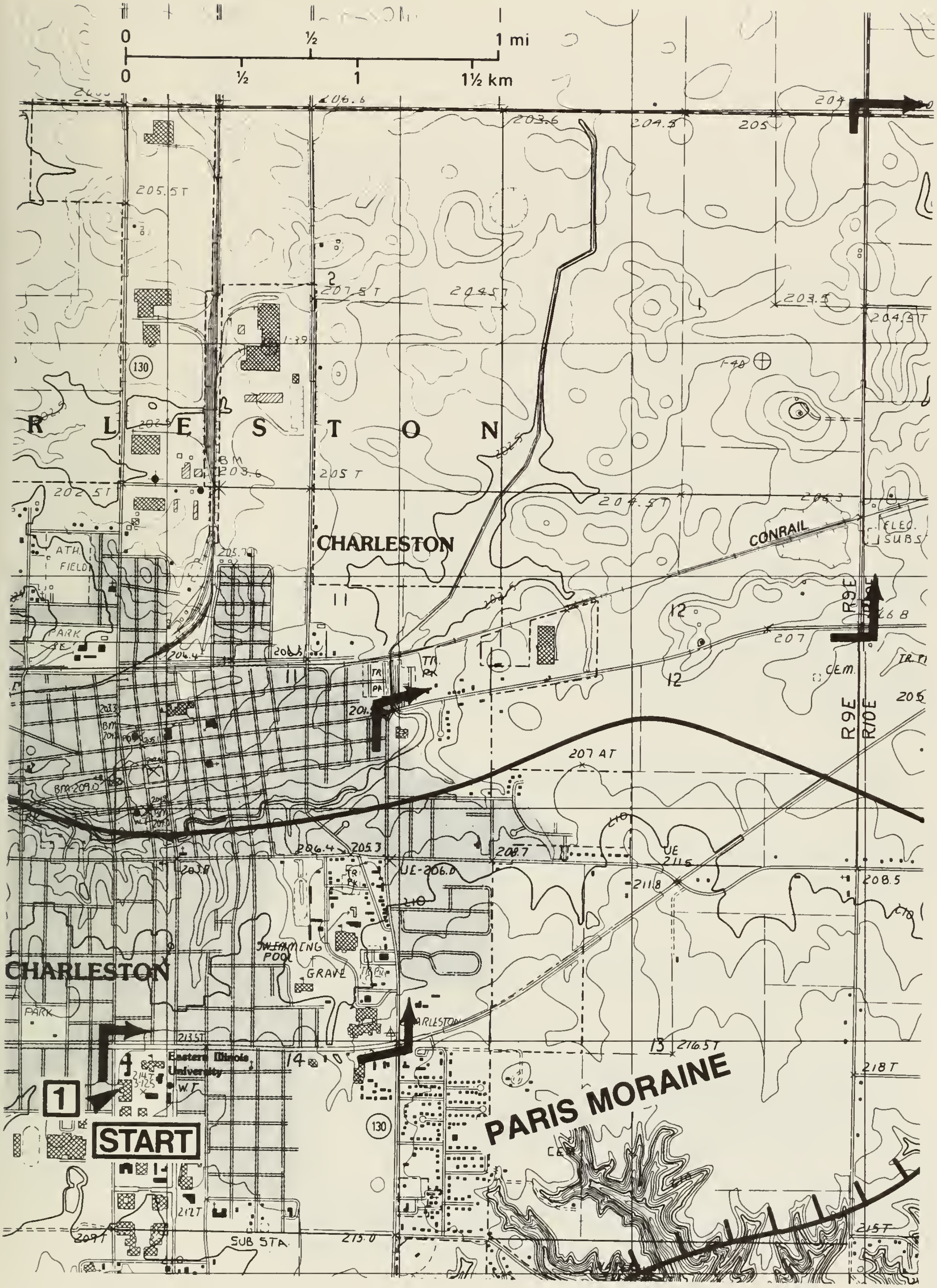
Figure 4. Stylized north-south cross section shows the structure of the Illinois Basin. In order to show detail, the thickness of the sedimentary rocks has been greatly exaggerated and the younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre-C) granites. They form a depression that is filled with layers of sedimentary rocks of various ages: Cambrian (C), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). The scale is approximate.

Groundwater. Water is to be found everywhere below the top of the zone of saturation (water table), but it cannot readily be withdrawn by wells at every location. Successful wells can be constructed only where strata are penetrated that will easily transmit their stored water to wells. Such water-yielding strata are called aquifers. All earth materials have the capacity to absorb and store water, but the ability of these materials to yield water to wells depends on the type, size, number, and degree of interconnection of pores and crevices present. Some earth materials, such as sands and gravels, coarse-grained sandstones, and highly creviced limestones have characteristics that make them particularly good aquifers. Other earth materials, such as clays, silts, and shales, may contain as much or more water per cubic foot in their pore spaces as sand and gravel, yet may yield little or no water because groundwater cannot move through the pore spaces into the well.

In this part of Illinois, based on data in the Survey's files, deposits of sand and gravel occurring in the glacial drift and in the bedrock valleys are important aquifers. The glacial drift is generally less than 50 feet thick; however, the sand and gravel deposits tend to be thinner and occur scattered as stringers and lenses within the glacial drift throughout most of the field trip area. Thicker glacial deposits occur in several south-trending valleys cut into the bedrock surface. Water-yielding sand and gravel beds occur in parts of these valleys. Thin glacial outwash gravels in the northern parts of the counties lying in front (that is, to the south) of the Shelbyville Morainic System also locally provide an adequate source for small groundwater supplies. Where glacial deposits yield water too slowly to supply the pump in a drilled well, the construction of a large diameter, bored well may be necessary to obtain an adequate water supply. This type of well holds a substantial reservoir of water below the water surface in the well to meet peak demands of a household.

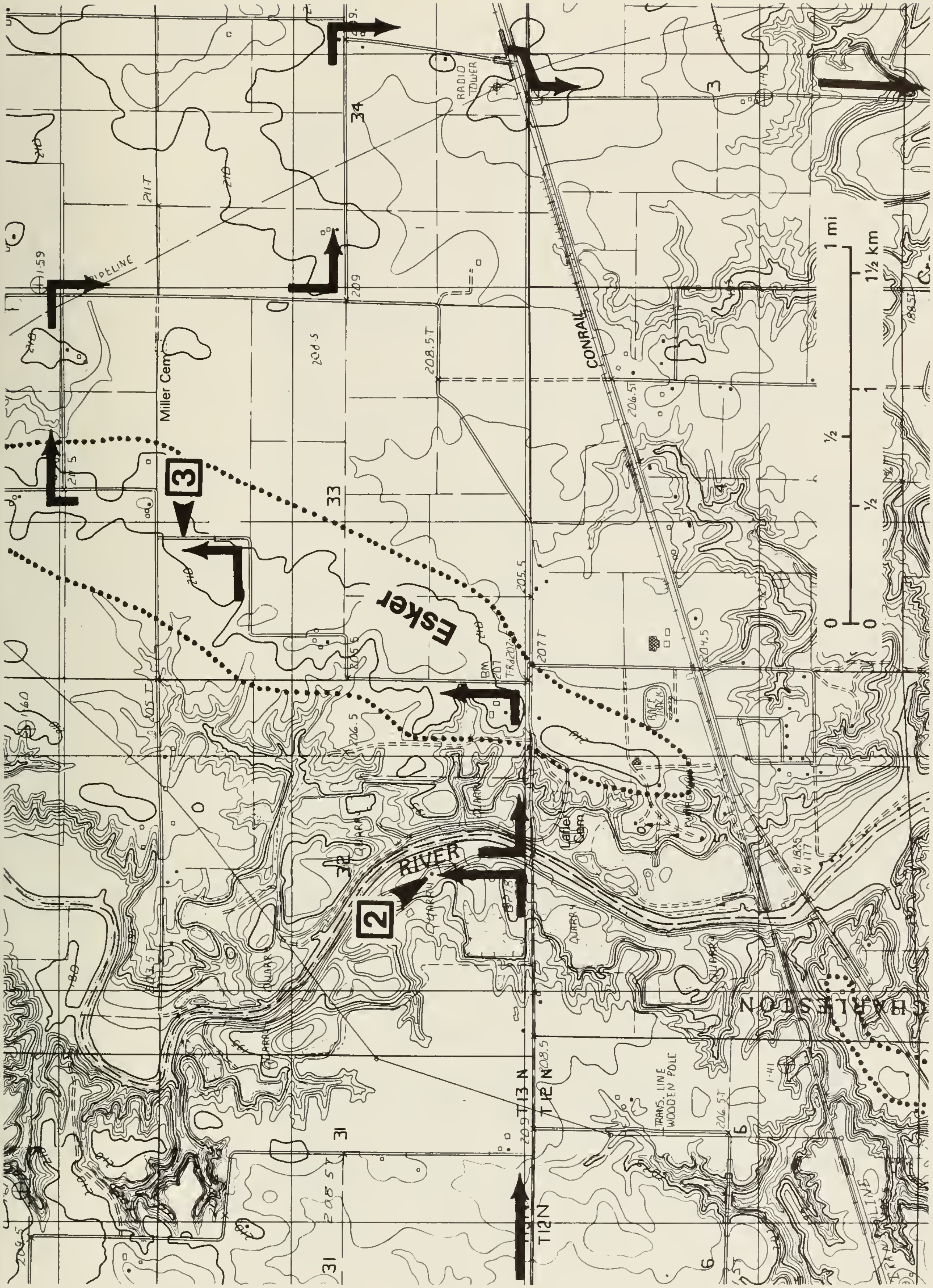
The uppermost bedrock in this area is part of the Pennsylvanian System and consists mostly of shale, but does contain a few interbedded layers of limestone, fine-grained sandstone, and coal. The shale yields little water. Small supplies of ground water are sometimes obtained from wells in sandstone or from wells that have encountered fractured limestone and coal beds.

In general, groundwater for domestic and farm supplies is available in the upper 150 to 200 feet of earth materials, from either sand and gravel in the glacial drift or sandstone, limestone, or coal in the bedrock of Pennsylvanian age. Drilling to greater depths encounters groundwater that is too highly mineralized for most uses.


0
½
1 mi
0
½
1
1½ km
R L E S T O N
CHARLESTON
CONRAIL
ELEC. SUBS
R9E
R10E
CEM.
ATH. FIELD
PARK
SWIMMING POOL
GRAVE
CHARLESTON
PARK
Eastern Illinois University
W.T.
1
START
SUB STA.
PARIS MORAINE
130
130
12
12
11
11
13
14
2
1
207 AT
208.5
218 T
215 T
213.0
212 T
209 T
204.5 T
205 T
205.5 T
202.5 T
203.6
204.5
205
203.5
204.5 T
206.4
205.3
208.7
211.8
216.5 T

GUIDE TO THE ROUTE

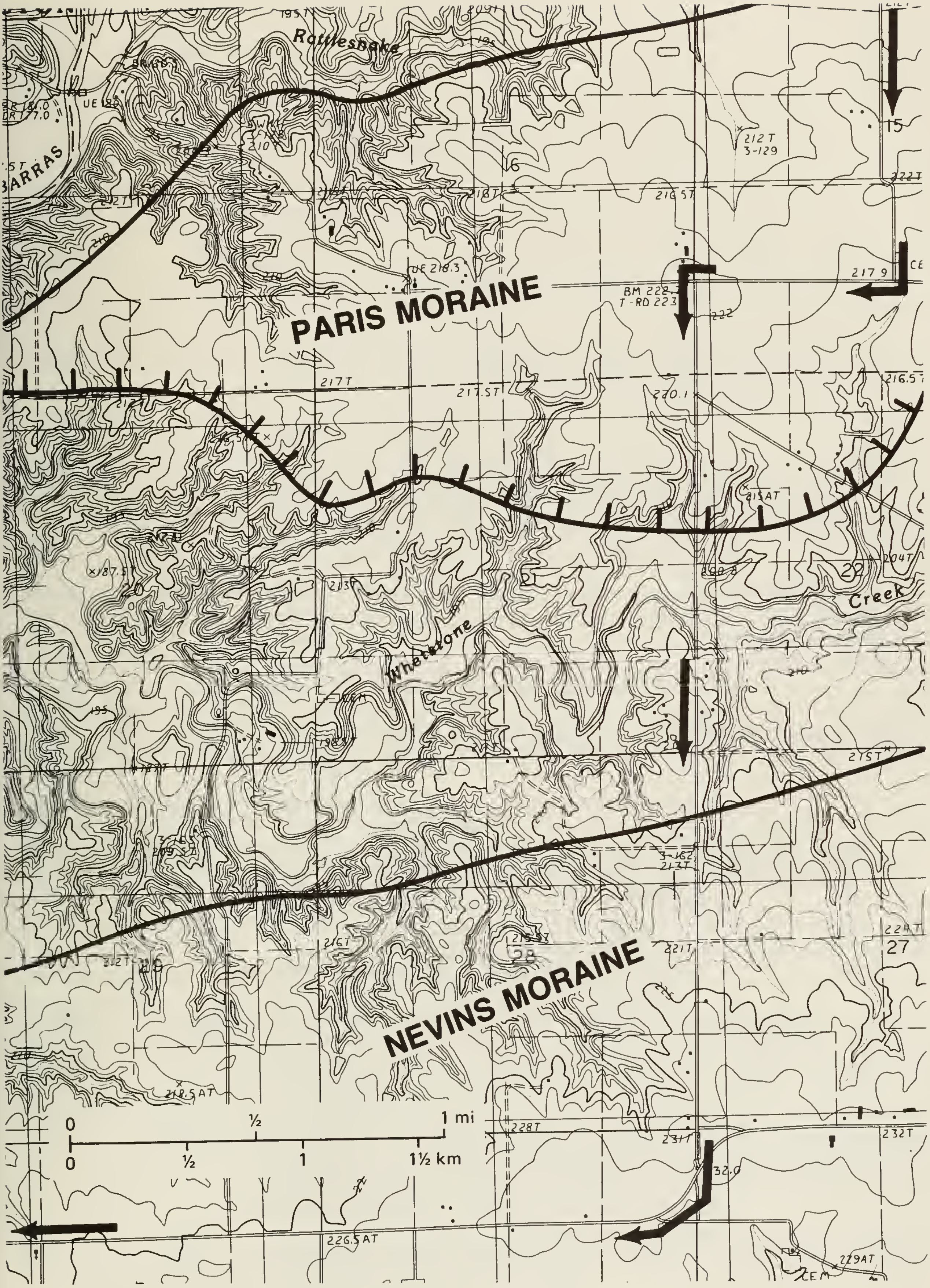
Miles to next point	Miles from start	
		Assemble in the parking lot on the west side of the Science Building, Eastern Illinois University, Charleston (second building on east side of South 4th Street, south of Lincoln; turn south at Hardee's).
0.0	0.0	**STOP 1.** Visit to hallway displays on 2nd and 3rd floors of the Science Building.
0.0	0.0	Leave Stop 1 and HEAD NORTH on South 4th Street.
0.1	0.1	CAUTION: Stoplight (Lincoln Avenue). TURN RIGHT (east) on Lincoln State Route (SR) 16 .
0.1	0.2	CAUTION: Stoplight (South 6th Street). Eastern Illinois University Old Main Administration Building to right. CONTINUE AHEAD (east).
0.05+	0.25+	CAUTION: Stoplight (South 7th Street). CONTINUE AHEAD (east). The route here lies slightly north of the crest of the Woodfordian Paris Moraine, the inner moraine of the Shelbyville Morainic System. It can be traced westward from the Indiana state line for about 50 miles (see Woodfordian Moraines map in Pleistocene Glaciations in Illinois in back).
0.6-	0.85	CAUTION: Stoplight (South 18th Street). TURN LEFT (north) on SR 130 and descend gentle backslope of the Paris Moraine.
0.9	1.75	STOP: 1-way (Madison Street). TURN RIGHT (easterly) on SR 316.
1.15	2.9	Prepare to turn left.
0.1	3.0	TURN LEFT (north) at T-road intersection (865N; 1800E).
0.3-	3.3-	Abandoned Conrail crossing.
0.05+	3.35	View to north-northwest is of a kame, an ice-contact landform (see p. 2, Pleistocene Glaciations in Illinois). Note its shape as viewed from different locations as we proceed along the road to the north.
0.25	3.6	Field to the northwest occupies a low sag in the Paris ground-moraine surface. It collects rainwater easily and retains it. Note the pipe drain standpipes in its lower parts to facilitate drainage.



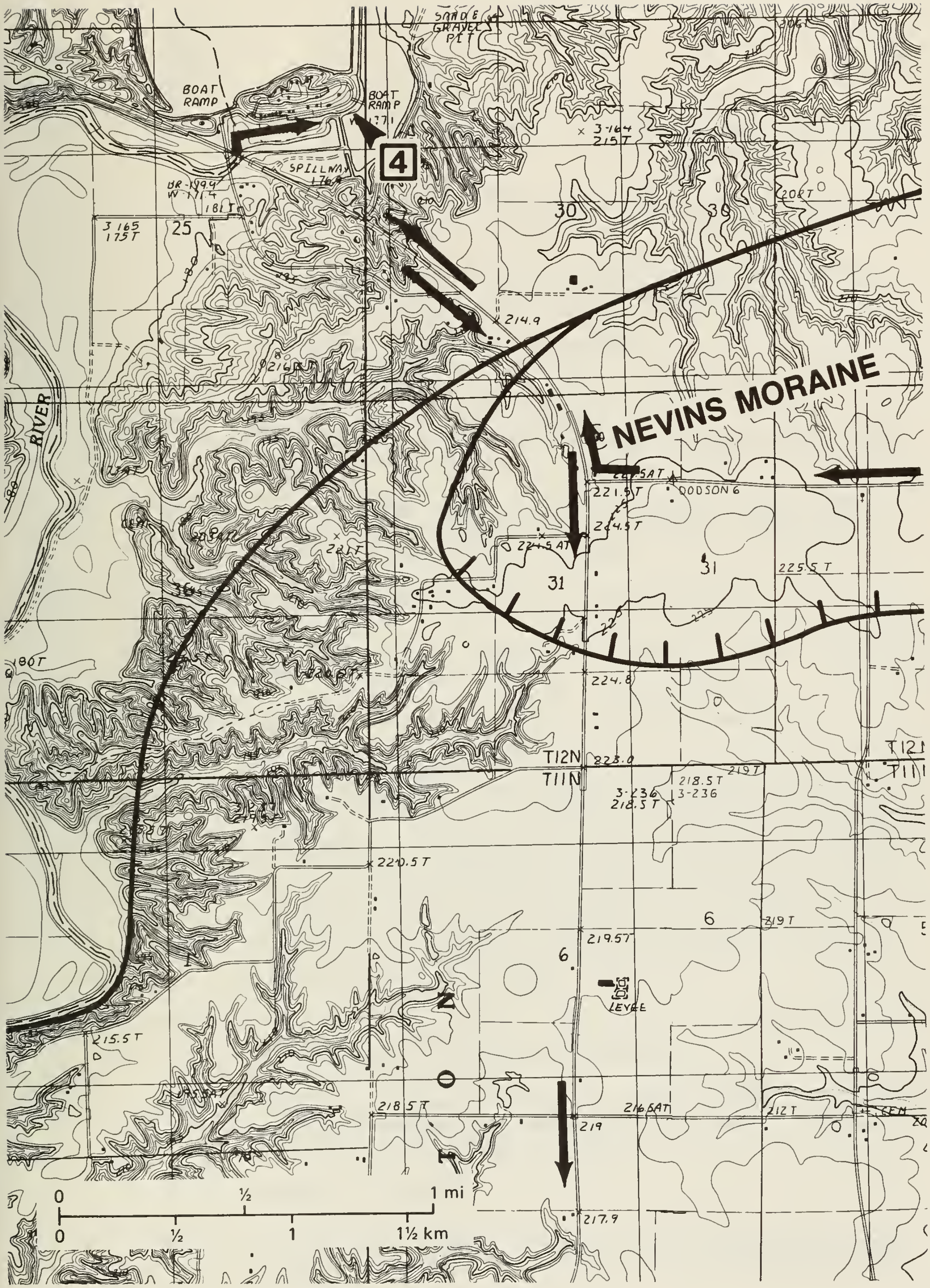
Esker
RIVER
CONRAIL
Miller Cem
RADIO TOWER
PIPELINE
TRANS. LINE
WOODEN POLE
CHARLESTON
QUARRY
T13N
T12N
2
3
0
½
1
1 mi
0
½
1½ km

Miles to next point	Miles from start	
0.4	4.0	The Paris ground moraine in this area is marked by numerous small, low hills and shallow sags across its surface. The Cerro Gordo moraine is the higher ground about 6 miles northwest from this locality.
0.35+	4.35+	CAUTION: unguarded crossroad (1000N; 1800E). TURN RIGHT (east).
1.25	5.6+	Roadcut on the right is through Wisconsinan till of the Wedron Formation. Note the glacial erratic, a 6-inch cobble, near the bottom of the exposure on the right.
0.1-	5.7	The pond to the left is located in a former quarry pit that was operated about 1978 and has since been reclaimed.
0.2+	5.9+	STOP: 2-way; crossroad (1000N; 1950E). TURN LEFT (north) with CAUTION--large trucks loaded with stone have the right-of-way.
0.25	6.15+	Office of the Charleston Stone Company. You MUST have permission to enter this property.
		STOP 2. Operating quarry in the Pennsylvanian Livingston Limestone Member of the Bond Formation.
0.0	6.15+	Leave Stop 2; CAUTION: retrace route to crossroad.
0.25	6.4+	CAUTION: TURN LEFT (east) at crossroad (1000N; 1950E) and cross old, single-lane iron bridge over the Embarras (pronounced Ambraw) River.
0.05+	6.5-	CAUTION: quarry haulage crossroad. CONTINUE AHEAD (east) and ascend the east valley wall of the Embarras River.
0.35	6.85-	CAUTION: entrance to Charleston Stone Company plant on the right.
0.05+	6.9+	TURN LEFT (north) at T-road intersection (1000N; 2000E).
0.15-	7.05	The route for the next 1.7 miles will be along and across an elongate surface feature called an esker.
1.15	8.2	**STOP 3.** View and discussion of glacial ice-contact features.
0.0	8.2	Leave Stop 3. CONTINUE AHEAD (north).

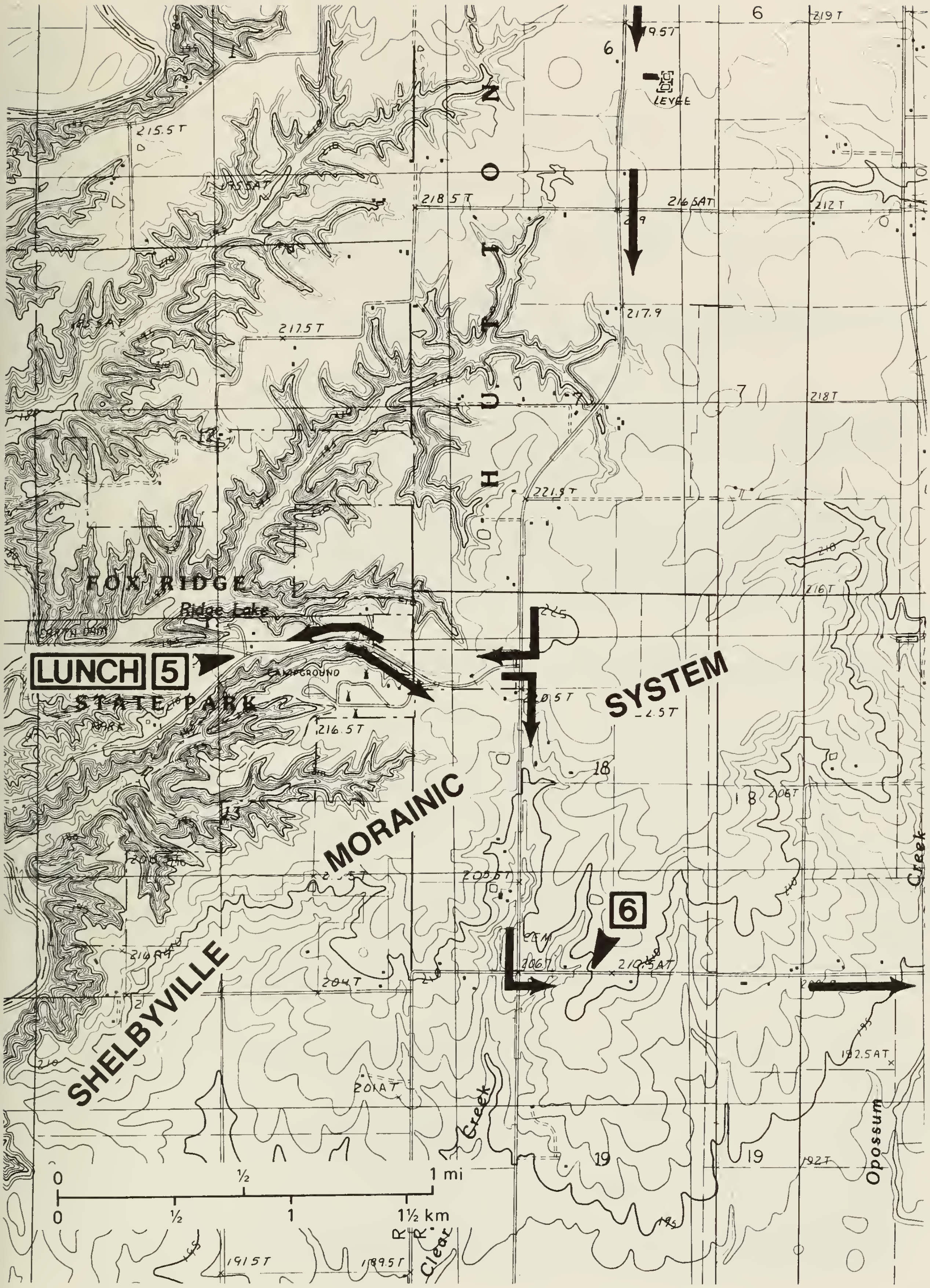
Miles to next point	Miles from start	
0.05+	8.25+	CAUTION: unguarded T-road intersection (1100N; 2040E). TURN RIGHT (east).
0.35+	8.65-	TURN RIGHT (east) at T-road intersection (1130N; 2050E).
0.5+	9.15-	CAUTION: T-road intersection (1130N; 2100E). TURN RIGHT (south).
0.75+	9.9-	TURN LEFT (east) at T-road intersection (1050N; 2100E).
0.7	10.6-	TURN LEFT (south) at T-road intersection (1000N; 2170E).
0.45+	11.05-	STOP: 1-way; T-road intersection (1000N; 2170E). TURN RIGHT (westerly) on SR 16 and prepare to turn left.
0.1	11.15-	TURN LEFT (south) at T-road intersection (1000N; 2150E).
0.95+	12.1	Glacial till exposed to left in roadcut.
0.15-	12.25-	Cross Polecat Creek. To the right is an exposure of Pennsylvanian sandstone belonging to the Mattoon Formation. This sandstone occurs above the Livingston Limestone seen at the Charleston Stone Company quarry. The identification of isolated Pennsylvanian rock exposures of a single lithologic type, especially sandstone, is extremely difficult for a variety of reasons. Sandstone usually lacks fossils which are an important identification tool; grain size, bedding structures, color, etc. of sandstones may be very similar even though the units are known to occur at different stratigraphic horizons; bedrock structure in an area may displace known correlatives many feet vertically within very short horizontal distances; this has to be taken into account in Coles County because of its location along the La Salle Anticlinal Belt. The same comments pertain to many clay, shale, and siltstone units except that fossils may be common and color may be fairly persistent in some shale units. Limestone commonly contains enough fossils to make identification fairly easy in limited geographic areas. Plant fossils, especially spores, are helpful for recognition of particular coal beds; however, it takes longer to make the identification because of the involved chemical maceration necessary to free the botanic components for microscopic analysis. If coals are close together stratigraphically (vertically), the botanical components may be so similar as to make positive identification nearly impossible.
0.95+	13.2	Ascend the gentle backslope of the Paris Moraine.


PARIS MORAINE
NEVINS MORAINE
Rattlesnake
Whetstone
Creek
EMBARRAS
0
½
1 mi
0
½
1
1½ km

Miles to next point	Miles from start	
0.4+	13.6+	CAUTION: road jogs left and then right along the crest of the Paris Moraine.
0.3-	13.9	CAUTION: T-road intersection (720N; 2150E). TURN RIGHT (west).
0.5+	14.4+	CAUTION: T-road intersection (720N; 2100E). TURN LEFT (south) on Coles County Highway (CoCH) 17 from the crest of the Paris Moraine.
0.65-	15.05+	Roadcut to left shows very pebbly till. Route is close to the outer margin of the Paris Moraine.
0.2+	15.3	Cross Whetstone Creek.
0.6	15.9	Ascend the backslope of the Nevins Moraine, the inner moraine of the Shelbyville Morainic System. It is separated from the other moraines by narrow depressions and is traceable for about 40 miles.
0.85+	16.75+	STOP: 1-way. T-road intersection on S-curve of Westfield Road (490N; 2100E). CAUTION: TURN RIGHT (southwest and then west). This is the highest point on the field trip, 761 feet m.s.l. The route here is along the crest of the Nevins Moraine.
2.6	19.35+	STOP: 1-way. T-road intersection (480N; 1850E). TURN RIGHT (northerly) on SR 130.
0.75	20.1+	Descend east valley wall of Embarras River.
0.2	20.3+	The new roadcut to the left is quite unstable and subject to slumping. Drainageways down the face have gullied and then been lined with coarse rock. The additional weight placed on the lower part of the slope has caused additional slumping of the glacial materials when they become saturated with groundwater.
0.35	20.65+	Cross Embarras River and prepare to turn right.
0.05	20.7+	TURN RIGHT (north) at entrance (570N; 1760E) to Lake Charleston.
0.1	20.8+	At the turn to the right here, the route is crossing the earthen dam constructed across the former channel of the Embarras River. Lake Charleston to the left is the water supply for the City of Charleston.
0.1-	20.9	BEAR LEFT (easterly) on the blacktop just beyond the Y-intersection from the left.

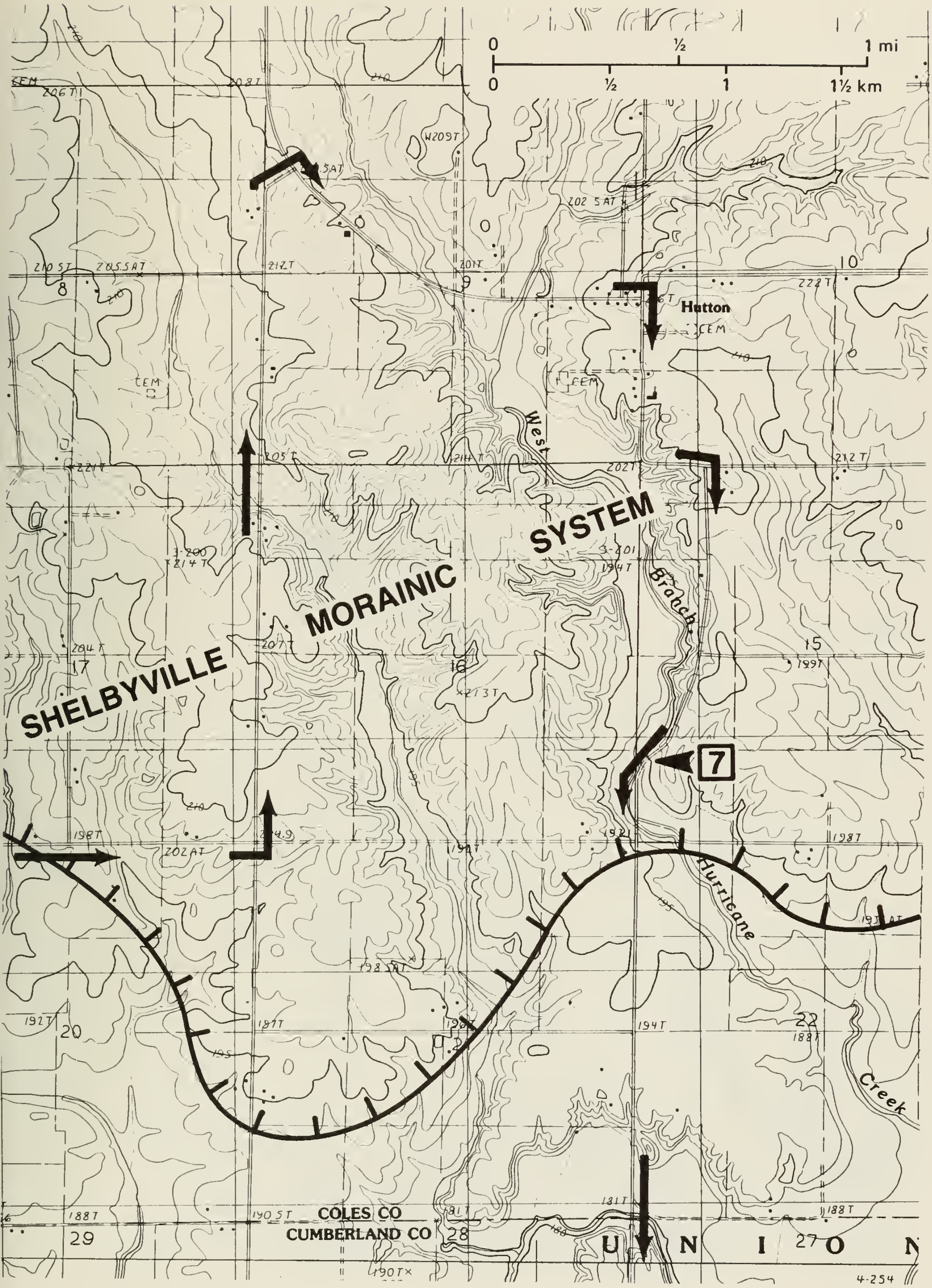

SAND & GRAVEL PIT
BOAT RAMP
BOAT RAMP
4
SPILLWAY
NEVINS MORAINE
RIVER
DODSON 6
LEVEE
T12N
T11N
0
½
1 mi
0
½
1
1½ km

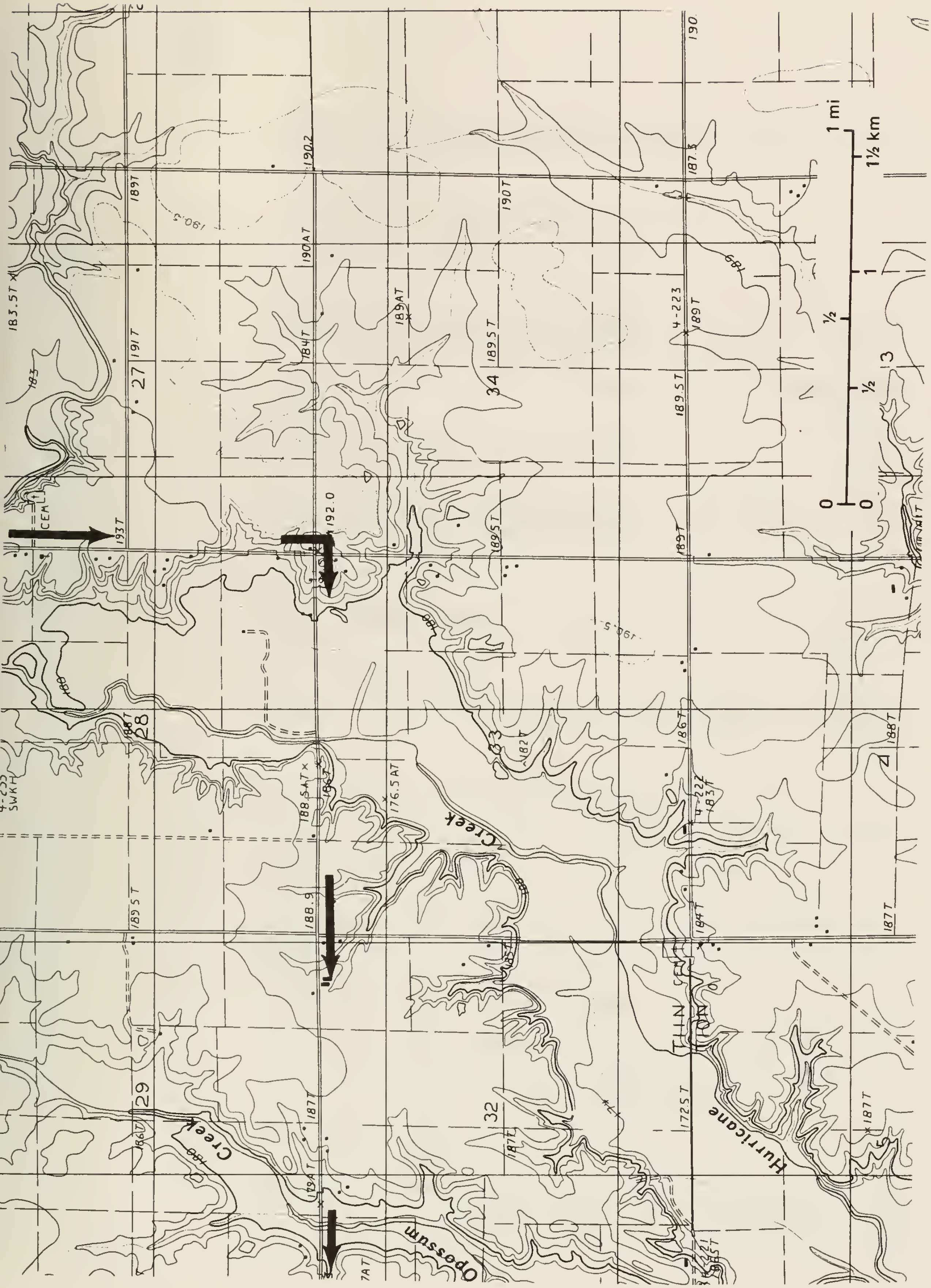
Miles to next point	Miles from start	
0.2+	21.1+	**STOP 4.** Lake Charleston and Embarras River dam discussion.
0.0	21.1+	Leave Stop 4. CONTINUE AHEAD (northeasterly) and curve left.
0.05+	21.15+	View ahead (north) from curve of the levee separating Lake Charleston (left) from Embarras River.
0.05-	21.2-	CAUTION: ascend very steep hill.
0.25	21.45-	CAUTION: descend very steep hill.
0.05-	21.5-	BEAR RIGHT (northwesterly, west, and then south) from Y-intersection.
0.15+	21.65+	STOP: 2-way; crossroad (570N; 1760E). TURN LEFT (easterly) on SR 130 and cross Embarras River bridge. CAUTION: cross-traffic is fast.
1.05-	22.7	Ascend gentle backslope of Nevins Moraine.
0.3+	23.0+	CAUTION: T-road intersection; Westfield Road. CONTINUE AHEAD (south) on SR 130.
0.45-	23.45	Leave the frontal margin of the Nevins Moraine.
1.55+	25.0+	The route crosses the headward portion of a small tributary to Embarras River. The stream valley is in a "youthful" stage of development, that is, its side walls are steep and abruptly intersect the gently undulating surface of the Shelbyville Morainic System. In cross-section, the valley approximates a "V" shape with little or no floodplain areas alongside the intermittent stream. The stream will continue to erode its valley headward and deepen its valley, especially during periods of heavy rainfall.
0.9-	25.9	Prepare to turn right. This is the approximate crest of the Shelbyville Morainic System here.
0.1-	26.0-	CAUTION: T-road intersection (180N; 1820E). TURN RIGHT (west) at entrance to Fox Ridge State Park. (Resume mileage figure at the entrance).
		STOP 5. LUNCH
0.0	26.0-	Leave Stop 5. STOP: 1-way; T-road intersection (180N; 1820E). CAUTION: fast traffic. TURN RIGHT (south) on SR 130.



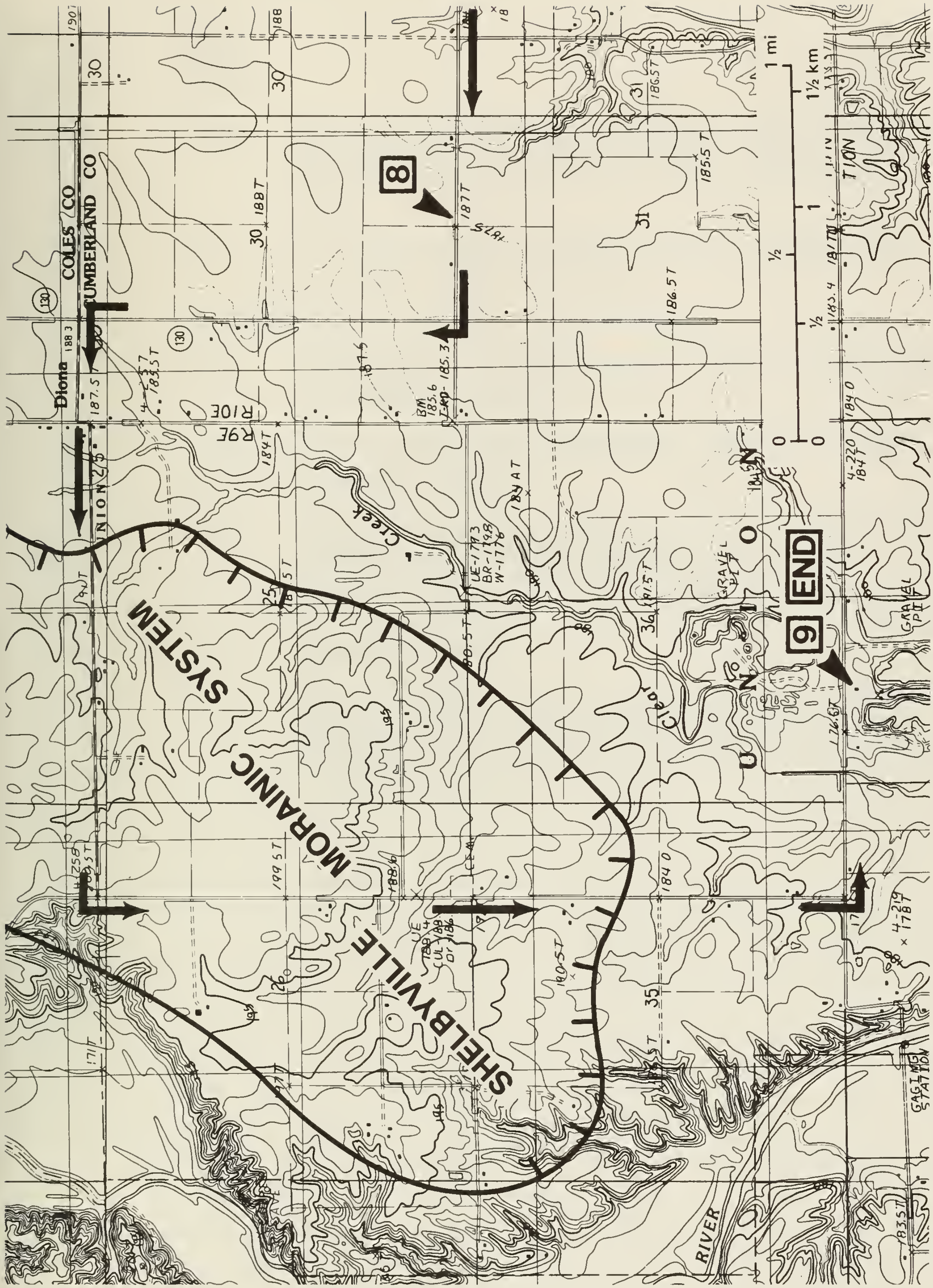
HUTTON
LEVEE
FOX RIDGE
Ridge Lake
LUNCH
5
CAMPGROUND
STATE PARK
SHELBYVILLE
MORAINIC
SYSTEM
6
Clear Creek
Opossum Creek
0
½
1 mi
0
½
1
1½ km

Miles to next point	Miles from start	
0.2+	26.2	Begin descent of Shelbyville Morainic System frontal margin.
0.5	26.7	Prepare to turn left.
0.1	26.8	TURN LEFT at crossroad (100N; 1820E) by Hurricane Baptist Church.
0.2	27.0	**STOP 6.** View to the right (south) from the Shelbyville Morainic System across the flat Illinoian till plain.
0.0	27.0	Leave Stop 6 and CONTINUE AHEAD (east).
0.1-	27.1-	Note to the right the glacial erratic at the farm lane. Banking of light- and dark-colored minerals indicates that the boulder is a gneiss.
0.8	27.9	CAUTION: narrow concrete bridge across Opossum Creek. The route now is at the approximate frontal margin of the Shelbyville Morainic System. Area to the right is part of the apron of outwash materials sloping gently southward.
0.2+	28.1+	Large granitic erratic at farm entrance lane to the right.
0.1-	28.2-	CAUTION: narrow concrete culvert obscured by weeds.
0.35+	28.55+	CAUTION: crossroad (100N; 2000E). TURN LEFT (north).
0.9	29.45+	CAUTION: narrow concrete culvert.
0.8-	30.25-	Note the large granite gneiss boulder in the yard south of the brick farmhome on the left.
0.15	30.4-	STOP: 1-way; T-road intersection (280N; 2000E) on the curve. TURN RIGHT (southeasterly) on the blacktop (CoCH #5).
0.7+	31.1+	Cross east fork West Branch Hurricane Creek and enter hamlet of Hutton.
0.3+	31.45-	CAUTION: T-road intersection (250N; 2100E). TURN RIGHT (south and then east).
0.55+	32.0+	T-road intersection (200N; 2120E). TURN RIGHT (south).
0.8+	32.85	Park along roadside. Do NOT block the field entrance lane to the right. Walk north along the east side of the field to:


0 ½ 1 mi
0 ½ 1 1½ km
Hutton
CEM
West
Branch
SYSTEM
MORAINIC
SHELBYVILLE
7
Hurricane
Creek
COLES CO
CUMBERLAND CO
U N I O N
8
9
10
15
16
17
20
22
27
28
29
4-254


Opossum
Creek
Creek
Hurricane
CEM
27
28
29
32
33
34
3
1 mi
1½ km
0
½
1
190AT
192.0
190.2
176.5 AT
189.5T
4-223

Miles to next point	Miles from start	
		STOP 7. Center School Section exposes Illinoian till, Sangamon Soil, and Wisconsinan till and loess along east stream bank.
0.0	32.85	Leave Stop 7. CONTINUE AHEAD (south).
0.15+	33.0+	Cross West Branch Hurricane Creek.
0.2-	33.2	Route crosses outwash material on the apron in front of the Shelbyville Morainic System.
0.85+	34.05+	Cross West Branch Hurricane Creek and enter Cumberland County.
1.0+	35.1-	TURN RIGHT (west) at crossroad.
0.05+	35.15	Descend east valley wall of Hurricane Creek. Note the wide valley flat developed here.
0.45-	35.6-	Cross Hurricane Creek.
1.3-	36.85+	Cross Opossum Creek.
0.7-	37.55+	Park along roadside.
		STOP 8. View of Wisconsinan Moraine front to right (north).
0.0	37.55+	Leave Stop 8 and CONTINUE AHEAD (west).
0.3	37.85+	STOP: 2-way; crossroad. TURN RIGHT (north) on SR 130.
0.9-	38.75	Prepare to turn left.
0.1	38.85	TURN LEFT (west) toward Diona at crossroad (000N; 1820E).
0.2	39.05	CAUTION: enter hamlet of Diona.
0.05+	39.1+	TURN LEFT (south) at T-road intersection.
0.05-	39.15	TURN RIGHT (west) at T-road intersection.
0.1-	39.25-	Cross Clear Creek.
0.25+	39.5	Ascend the frontal margin of a lobe of the Shelbyville moraine that extends southward along the Embarras River.


SHELBYVILLE MORAINIC SYSTEM
COLES CO
CUMBERLAND CO
Diona
8
9
END
U N I O N
Creek
RIVER
GRAVEL PIT
GAGING STATION
R9E
R10E
0
½
1
1 mi
1½ km

Miles to next point	Miles from start	
0.3	39.8	Note the rather hummocky topography on both sides of the road here along the upper surface of the lobe. The general surface of the moraine slopes gently to the south.
0.6	40.4	TURN LEFT (south) at T-road intersection (000N; 1680E) and reenter Cumberland County.
0.85-	41.25-	CAUTION: narrow concrete culvert.
0.55+	41.8	Crossing onto the outwash apron in front of the Shelbyville Morainic System.
0.6-	42.4-	STOP: 1-way; T-road intersection. TURN LEFT (east).
0.3+	42.7+	Cross Clear Creek.
0.2+	42.95-	TURN RIGHT (south) at entrance to C. and H. Gravel Pit. You MUST have permission to enter this property.

STOP 9. Study of Wisconsinan outwash sand and gravel.

END OF FIELD TRIP.

Turn right (east) upon leaving the entrance to return to SR 130. At SR 130, approximately 1 mile to the east, turn right to go to Greenup and I-70, or left to return to Charleston-Mattoon and I-57.

FIELD TRIP STOPS

STOP 1. Self-guided tour of hallway Earth Science displays in the Science Building, Eastern Illinois University, Charleston (SW¼ NW¼ NW¼ SW¼ Sec. 14, T. 12 N., R. 9 E., 3rd P.M., Coles County; Charleston South 7.5-minute Quadrangle).

North Wing, 3rd Floor display cabinets.

(1) Climatology
(2) Volcanology
(3) Satellite Image Maps

North Wing, 2nd Floor display cabinets

(1) Minerals and rocks
(2) Paleontology (including fossils from the Badlands, SD)
(3) Plate tectonics
(4) J. B. Phillips Mineral Collection

STOP 2. Discussion of Pennsylvanian bedrock exposed in an operating quarry of the Charleston Stone Company (Office: SE cor. NE¼ SW¼ Sec. 32, T. 13 N., R. 10 E., 3rd P.M., Coles County; Ashmore 7.5-minute Quadrangle).

The quarries on both sides of the Embarras River are mining the Livingston Limestone, the uppermost member of the Pennsylvanian Bond Formation. The Livingston correlates with the Millersville Limestone Member of the central and southwestern part of the Illinois Basin. Recent work tentatively correlates these units with the La Salle Limestone Member of north-central Illinois.

The Livingston occurs in the quarries that operated along both sides of the Embarras for a distance of about one mile. It and some shale that has been found just below it in the quarries, are the oldest Pennsylvanian strata exposed at the bedrock surface in the field trip area. These rocks have been brought close to the surface here by arching of the bedrock strata along the crest of the Tuscola Anticline, a part of the La Salle Anticlinal Belt. A generalized sequence of bedrock in the northeastern part of the quarry and adjacent areas follows:

Pennsylvanian System

McLeansboro Group

Missourian Series

Mattoon Formation

Shale - light greenish-gray, massive, calcareous with some limestone lenses near base, fossiliferous (brachiopods and bryozoans), 3 feet+

Bond Formation

Livingston Limestone Member

Limestone - light gray, dense to finely crystalline, irregular bedded to massive, fossiliferous (brachiopods, bryozoans, and crinoids), 6' - 12'

Shale - medium greenish-gray, finely silty, crinoidal, 8"

Shale - medium dark gray, mottled greenish, blocky to massive, 1'

Limestone - light gray, weathers greenish-gray, massive, dense, hard, fossiliferous (brachiopods, bryozoans, and crinoids), 2' - 7'

Shale - medium gray, 1' ±

Shale - dark gray to black, coaly, 6" ±

The Charleston Stone Company produces a wide range of products with a variety of particle sizes from coarse- to fine-grained for use as construction aggregates in portland cement concrete, asphalt cemented pavement, road base and shoulder applications, and rural road surfacings. In addition the quarry is an important source of agricultural limestone.

Sand and gravel is also excavated within the quarry property from deposits of Pleistocene age that occur above the Livingston Limestone. The sand and gravel is used for all quality-grades of fine aggregates, plus gravel for county road surfacing.

About 5 feet of Illinoian till and Sangamon Soil overlie the Livingston Limestone in this vicinity. Above the Sangamon Soil is a gravel deposit, 5 to 15 feet thick, that appears to have been deposited as sheet-like outwash in front of the advancing Shelbyville glacier. Another possible mode of deposition of the sand and gravel is that at least the upper portions of the deposit may be part of a sub-glacial drainage network that developed during the deposition of the Shelbyville Morainic System when the waning glacier stood close to this locality.

STOP 3. Discussion of ice-contact features of the Shelbyville glacier (West edge SW¼ NE¼ NE¼ NW¼ Sec. 33, T. 13 N., R. 10 E., 3rd P.M., Coles County; Ashmore 7.5-minute Quadrangle).

As noted at Stop 2, at least part of the sand and gravel mined from this vicinity occurred in deposits that may have been part of a sub-glacial drainage network of the Shelbyville glacier. For slightly more than a mile before stopping here the route has followed and crossed portions of an elongate ice-contact feature called an esker. Eskers form either in ice-enclosed elongate tunnels beneath a glacier or in tubes within the ice. The sand and gravel that are being carried along by glacial meltwater eventually fill the

enclosure so that water movement is slowed to a trickle. As the ice continues to melt, open crevasses nearby carry the meltwater away from the ice front. Melting eventually lowers the sand and gravel deposited in the tubes and tunnels onto the underlying ground moraine, draping them across that slightly irregular surface.

The southern portion of this esker was mined many years ago in the area of the racetrack marked on your route map. Gravel was also mined west of the river from deposits that may have been an extension of this esker before the Embarras River cut its valley through the moraine.

Eskers are fairly rare in Illinois, and when present, commonly are quite short. The longest at 5.5 miles is the Kaneville Esker about 5 miles west of Batavia, Kane County.

Between Stops 1 and 2, the route crossed the ground moraine left by the melting Shelbyville glacier. Several roughly conical mounds called kames can be seen along that part of the route. These also are ice-contact features. Sediment-laden meltwater rushing off of the ice deposited the coarser part of its load at the ice front, building a steep-surfaced delta ramped up against the ice. When the ice eventually melted, the sediments slumped into the roughly conical shaped mounds we now see.

STOP 4. Discussion of Lake Charleston and its geologic setting (S½ SE¼ NE¼ NE¼ Sec. 25, T. 12 N., R. 9 E., 3rd P.M., Coles County; Charleston South 7.5-minute Quadrangle).

AN OVERVIEW OF THE SPILLWAY FAILURE, LAKE CHARLESTON, ILLINOIS

The Charleston area is located in east-central Illinois, an area that has been subjected to several episodes of continental glaciation. There is ample evidence of the last two glaciations: 1) the Illinoian, which lasted from 300,000 y.b.p. to 175,000 y.b.p.; and 2) the Wisconsinan, which lasted from 75,000 y.b.p. to 12,000 y.b.p. The most prominent glacial feature in the area is the Shelbyville Morainic System, a terminal moraine that marks the southernmost advance of the Wisconsinan glacial episode. The morainic system is composed of a series of nested, lobate, east-west trending ridges, extending approximately 100 miles from the Indiana border into central Illinois. In a north-south direction the moraine averages 5 to 7 miles in width and rises to a height of 100 to 200 feet above the Illinoian till plain to the south. In this area the morainic system is breached by two main rivers, the Embarras River near Charleston and the Kaskaskia River near Shelbyville.

The Embarras and Kaskaskia Rivers probably originated when glacial melt-water that was ponded behind the moraines breached a low area in the ridge and began to cut into the morainal deposits. As the streams incised they became entrenched at their present positions in the moraines and began to widen as well as deepen their valleys. As the streams approached their present elevation they encountered Pennsylvanian-age bedrock under the glacial till. The more resistant bedrock caused constrictions in the valleys where bedrock was encountered (fig. 5A). The constrictions in the valleys where the rivers cut

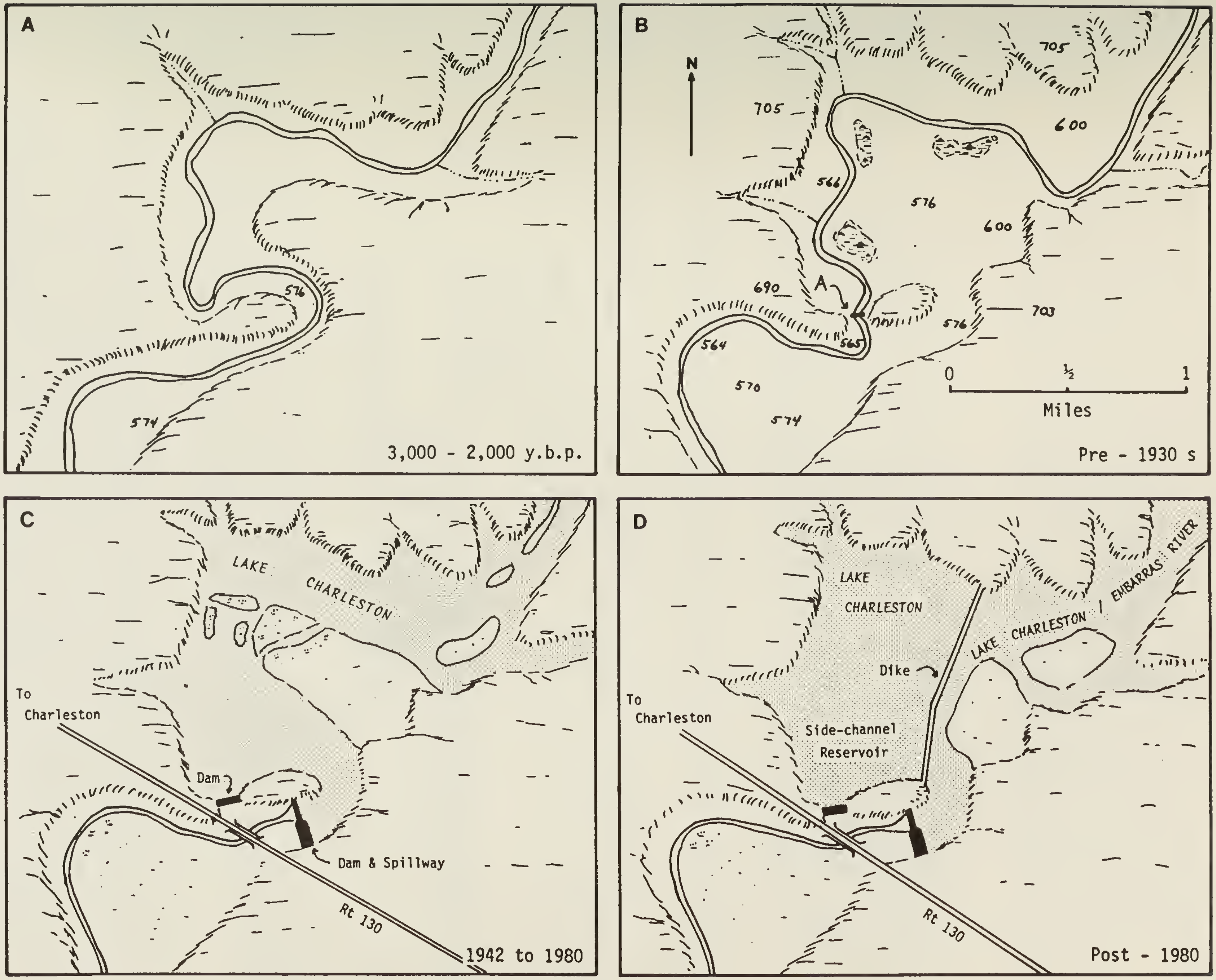


Figure 5. (A) The route of the Embarras River prior to the meander cutoff, (B) the valley of the Embarras River after the meander cutoff, (C) the original Lake Charleston, 1942 to 1980, and (D) Lake Charleston after completion of the side-channel reservoir.

through the moraines were ideal sites for dams, and over the years there have been several dams constructed at each site.

Local people have utilized the river for many purposes over the last century. Earliest uses were downstream flatboat transport of locally produced goods, near-stream water supply and even a button factory that used the shells of freshwater mussels from the river as raw materials. One of the first modifications to the Embarras River came in the mid 1800s when a small dam was built across the river near the bridge on SR 130. The dam served to impound water to power a gristmill (fig. 5B, point A). The location was at a bedrock-cored meander cutoff. It provided a channel constriction and a nearby source of stone for the dam.

By the mid 1930s the population of Charleston had reached the point where the groundwater that had been used as the municipal water source was not adequate for the growing town and the expanding university. Plans were developed for a larger, more reliable water supply. The decision was made to construct a dam at the site of the old gristmill. An additional dam and spillway were constructed in the old abandoned meander bend, 1/3 mile to the east (fig. 5C). The expectations were that Lake Charleston would provide the city with adequate fresh water for many decades.

By the 1960s it became apparent that Lake Charleston was filling with sediment at an unexpectedly high rate (see table 1).

Table 1. Changes in capacity of Lake Charleston (from C. T. Yang, 1974).

Year	Capacity (in gallons)
1947	744,000,000
1960	455,000,000
1964	404,000,000 (1' wooden boards were installed on top of the spillway to increase storage capacity to 531,000,000 gallons)
1974	413,000,000 (with 1' wooden boards)
	281,000,000 (without 1' wooden boards)

Sediment from the 787 square mile drainage basin above Charleston was rapidly filling the lake and by 1974 it had lost over 60 percent of its original capacity. Once again the fresh water supply for the still-growing town and university population was being threatened.

In the mid 1970s a plan was developed to create a reservoir that would not trap sediments as quickly as the original Lake Charleston. The plan was to build a "side-channel reservoir" (fig. 5D). In a side-channel reservoir system, a dike is used to isolate the reservoir part of the lake from the sediment-laden river. Water is then pumped from the impounded river into the reservoir at a time when the river is relatively free of sediment. During high flow periods, when the river is carrying a large volume of suspended load, there is no pumping and the sediment load passes over the spillway without entering the side-channel reservoir. The impounded river portion of the lake is still subject to siltation, but only up to a depth where there is

sufficient flow velocity to maintain entrainment of particles through the lake. The side-channel reservoir system for Lake Charleston was completed in 1980 and appeared to be a long-term solution to Charleston's water supply problems.

During November of 1985 the Charleston area was subjected to a series of weather fronts that brought record rainfalls totalling 10 inches for the month. The rains kept the Embarras River at or above bankfull discharge for approximately 10 days. This situation caused unusually high stress on the 40-year old spillway structure.

On November 21, 1985, the 76-ton concrete slabs on the spillway slope began to shift. After 3 days, several of the lower slabs were forced into a vertical position by the hydraulic pressure of water flowing under, as well as over the spillway structure. As the lower slabs were forced out of place, the upper slabs slid down behind them. On November 25th, five days after the initial shifting of the concrete slabs, the entire discharge of the river began to flow under the spillway crest causing the lake to drain into a plunge pool that began to creep upstream. Two days later (Nov. 27) an 80-foot section of the spillway crest collapsed. This increased the rate at which lake level dropped and caused the headcut to migrate to a point approximately 75 feet upstream from the spillway.

One week after the initial signs of failure, the headcut had progressed 75 to 100 feet upstream and had begun to divide into two channels (fig. 6). At this time city officials became concerned that progressive headward erosion could endanger the water intake pipes, pumphouse the side-channel dike that impounds the main reservoir. On December 4th, construction began on a series of finger dikes which would force the main current, and therefore the headcut, away from the intake pipes and the side-channel dike.

By December 6th, eleven days after the spillway failure, the headcut had progressed upstream approximately 500 feet. Prior to this time, upstream migration of the headcut had been on the order of 45 feet per day. In the next two days (Dec. 6 to Dec. 8th) the rate of movement increased dramatically. The headcut moved an additional 900 feet in 48 hours, resulting in a channel 1,400 feet long, 50 feet wide and 10 feet deep (fig. 6). In the next seven days the headcut and plunge pool remained relatively stationary--there was only 50 to 100 feet of upstream movement. However, the plunge pool expanded from 50 feet to over 100 feet in width.

On December 15th, the headcut began to move upstream once again and on December 18th, after eroding back 600 feet in 3 days, reached an area underlain by a resistant sandstone. At this point the progression of the headcut was effectively halted. The finger dikes had kept the high velocity flow away from the intake pipes and, most importantly, the side-channel dike was intact, preserving Charleston's main water supply. Nonetheless, the city was left with a damaged spillway, a 2,000-foot long, 50-foot wide, 10-foot deep channel where the river impoundment used to be and a reservoir that was still in jeopardy. The side-channel reservoir remained a concern to the city because several small seeps were found in the dike and the Embarras River might still erode laterally into the dike.

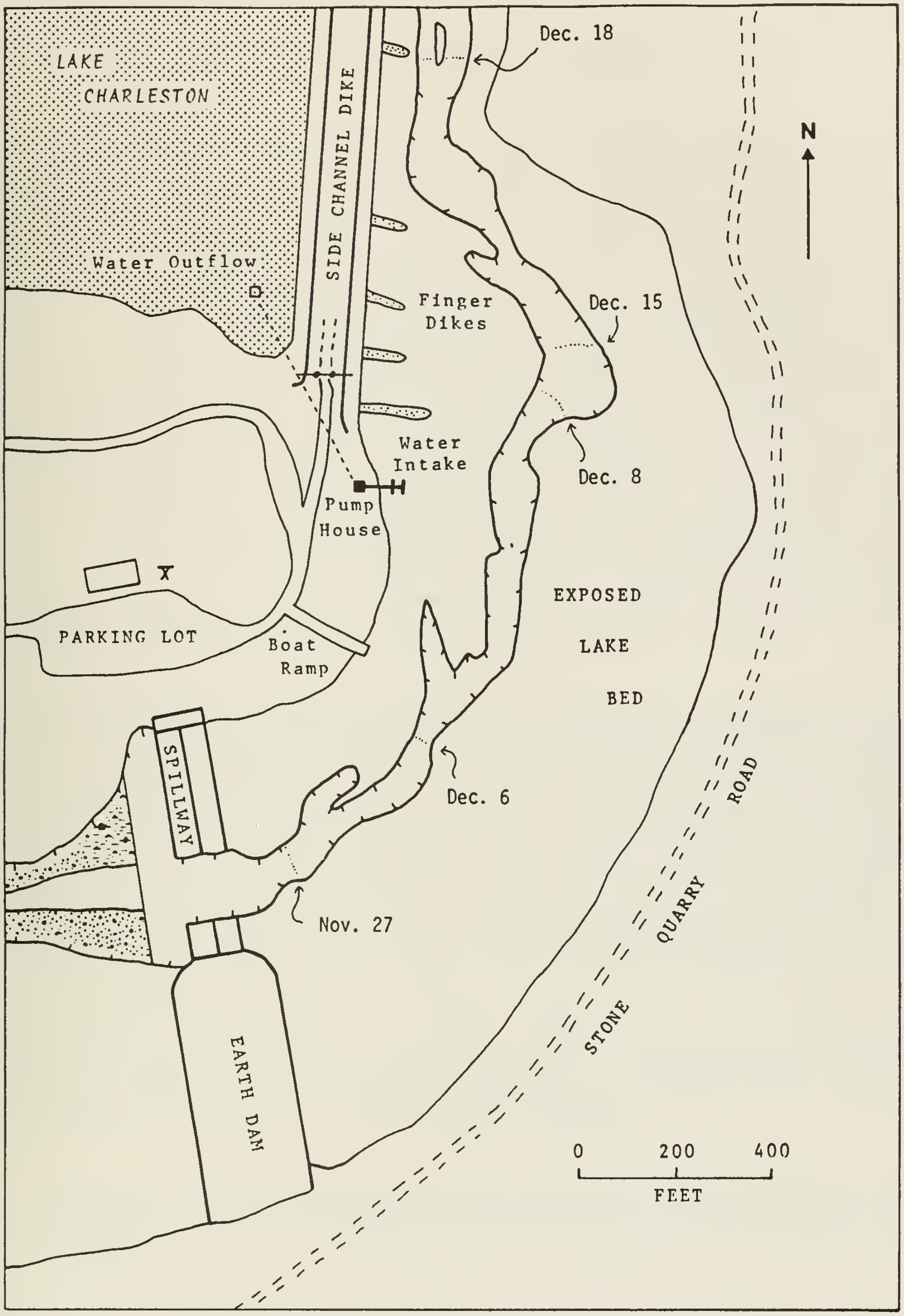


Figure 6. Map of the Lake Charleston spillway area showing the various positions of the migrating headcut along the incised channel.

Failure of the spillway provided an opportunity for firsthand observation of the old lake bed. The newly incised channel allowed inspection of both recent silt and the original meander bend sediments.

Numerous questions arose during the dam failure and the subsequent channel incision. One question dealt with the variable rate of headcut migration. Why did the headcut move quickly at some times and slowly at other times? Figure 6 shows the position of the headcut at various times during late November and early December, 1985. As can be seen, it took 11 days (Nov. 25 to Dec. 6) for the headcut to move approximately 500 feet, then in two days (Dec. 6 to Dec. 8) it moved approximately 900 feet. In the following seven days (Dec. 8 to Dec. 15) it moved only 100 feet, while during the next three days (Dec. 15 to Dec. 18) it moved upstream 600 feet. Information shown in figure 7 helps to explain the variable rate of migration. The stippled pattern indicates an area of old stream terrace soils. In general, we could say the soil is older than the soils directly to the east, it contains a hardened clay pan and is somewhat cemented by clays and iron. When the headcut was cutting through the old terrace soils, the rate of migration was quite slow (45 feet per day from Nov. 22 to Dec. 6; 14 feet per day from Dec. 8 to Dec. 15). When the headcut was incising the younger, uncemented alluvial fill, migration was much faster (450 feet per day from Dec. 6 to Dec. 8; 200 feet per day from Dec. 15 to Dec. 18). Thus it is clear that rate of migration of the headcut was related to the types of alluvial materials found in the old meander bend/lake bed.

Another question was directed to the amount of sediment the lake had collected over the past 40 years. Several transects were taken to determine the thickness of the recent sediments. Figure 7 shows the position of the transects and figure 8 shows the cross sections. In each transect, the old, high terrace is seen on the west side of the profile. The east side of the meander bend/lake bed was the last place occupied by the old Embarras River and was the lowest spot in the abandoned meander bend. Thus, the thickest recent lake sediments are found on the east side of the lake. Assuming a relatively flat upper surface for the lake sediments, at its deepest point sediment was approximately 8 feet thick. The cross sections also show that the lake was near the stable depth where there would be little further sedimentation.

As of the date of this field trip, November 1986, repair of the damaged spillway remains incomplete. A cofferdam has been built as part of the reconstruction efforts. Plans are to rebuild the spillway at the same spot, with a crest at the same elevation as the previous spillway.

STOP 5. Entrance to Fox Ridge State Park (SE¼ SE¼ NW¼ NW¼ Sec. 18, T. 11 N., R. 10 E., 3rd P.M., Coles County; Charleston South 7.5-minute Quadrangle).

Lunch followed by examination of glacial erratics in concession stand area. The lunch stop is near the 2 shelters adjacent to the concession stand area about a mile west from the park entrance.

Fox Ridge State Park is located about 8 miles south of Charleston on the east side of the Embarras River where it cuts through the Shelbyville moraines.

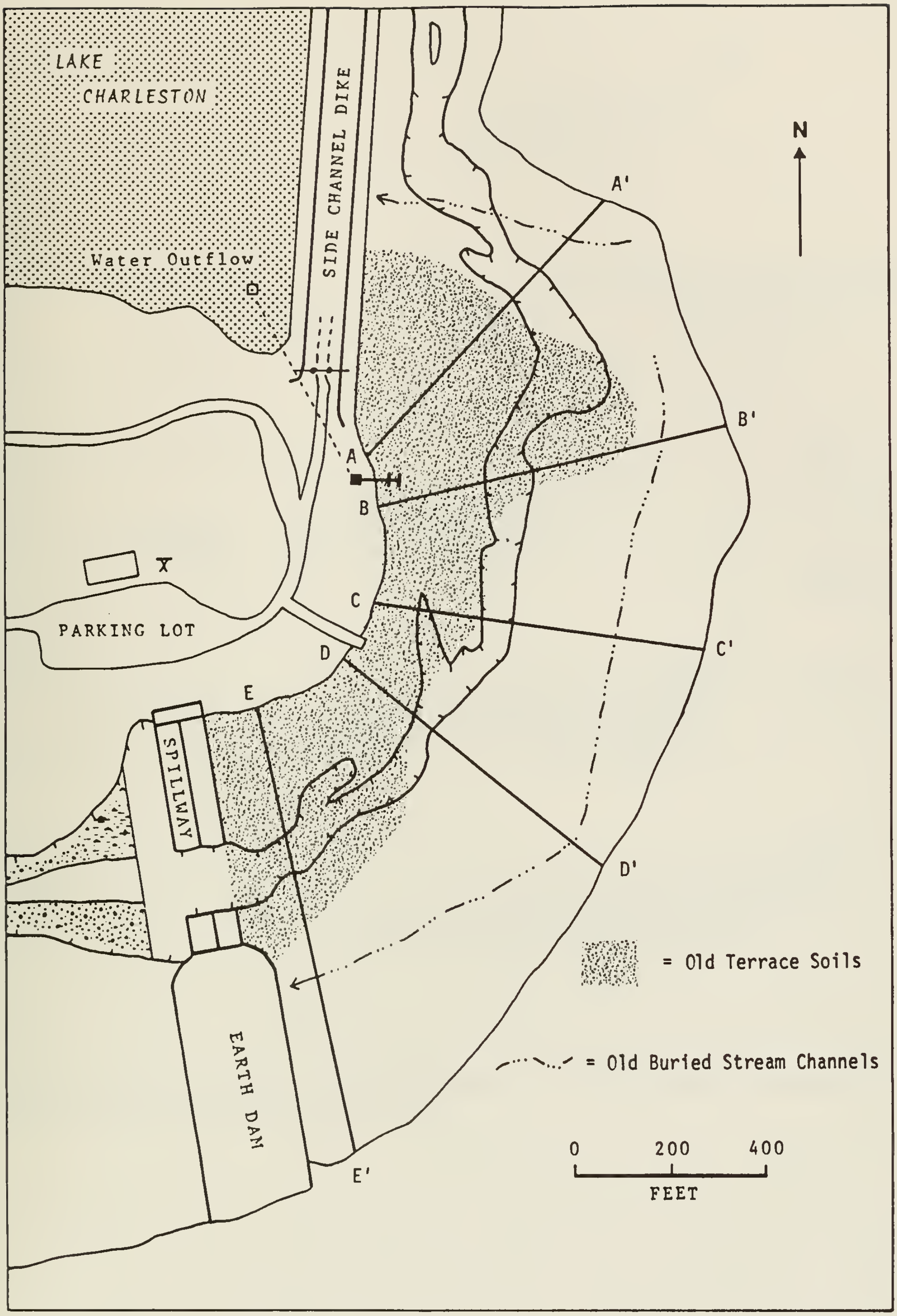


Figure 7. Map of the Lake Charleston spillway area showing the extent of the old Terrace soils and the locations of the sediment depth transects.

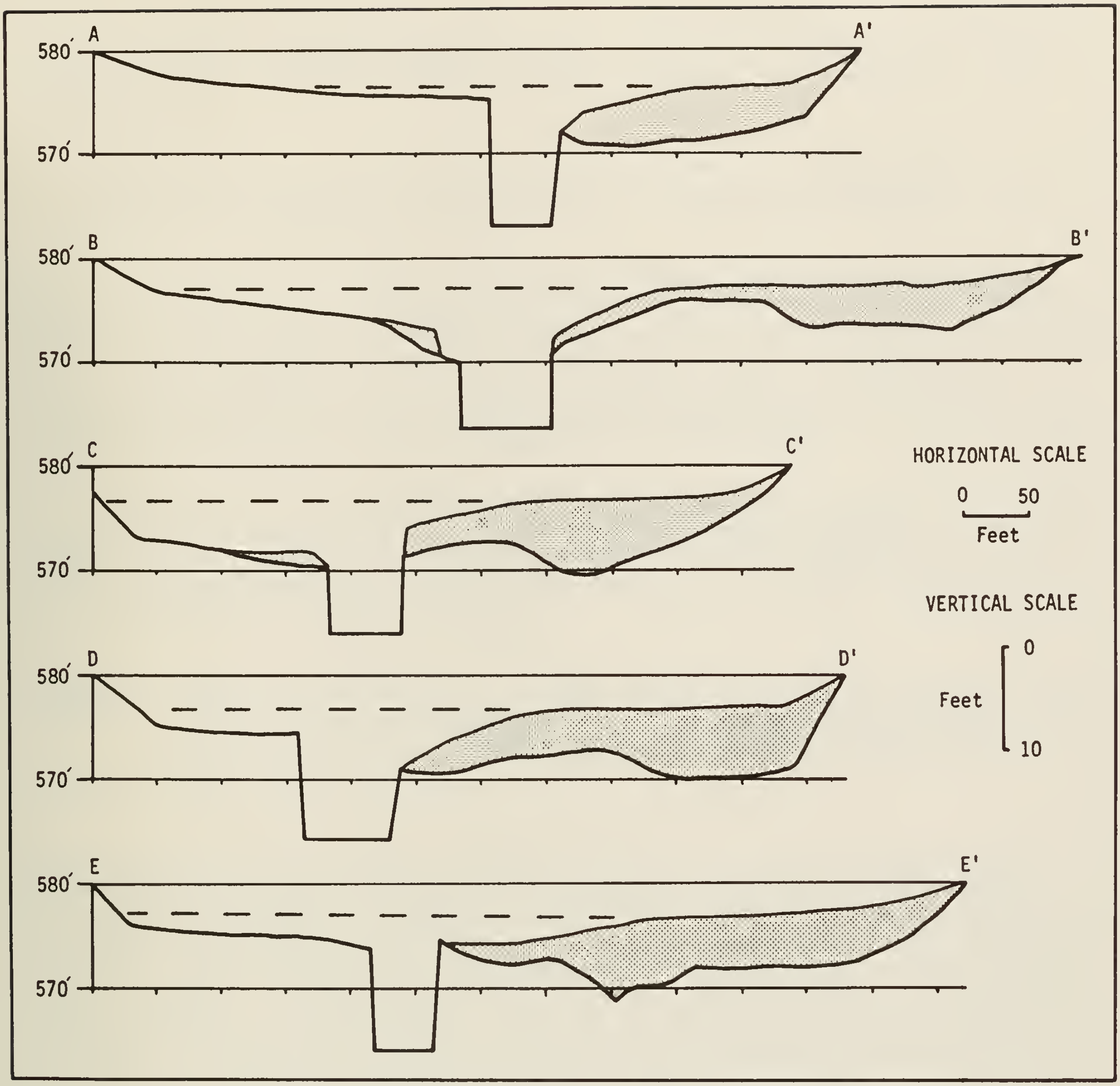


Figure 8. Cross sectional profiles across Lake Charleston illustrating the depth of sedimentation in the Lake (shading). Dashed line represents probable depth of sediment prior to the spillway failure.

The park consists of several hundred acres of heavily wooded land dissected by relatively short, steep, V-shaped tributary valleys to the Embarras. Scattered clearings along the narrow ridge tops separate the southwest-trending tributaries.

The State of Illinois assumed ownership and management of Fox Ridge State Park in 1938-39 from a group of Charleston citizens who had protected the area for future use as a state park.

Ridge Lake is an artificial lake of about 18 acres that has a shoreline of nearly 1.1 miles and a maximum depth of 25 feet. The clay-core dam is approximately 385 feet long with a concrete-lined spillway at its northern end. The Illinois State Natural History Survey administers the lake which was the first lake at which they were able to control the water level. Limnological research conducted here from a permanent field laboratory by our sister survey is designed to improve fishing in countless Illinois lakes.

The driveway and parking area at the concession stand are bordered with many glacial erratics (see Geogram 2 at the back of the guide leaflet). Most of these erratics are granite (igneous) or granitic gneiss (metamorphic) rock types, although there are 1 or 2 sedimentary rocks. How many of these rocks can you identify by type? By name?

STOP 6. View of the Illinoian till plain from the Shelbyville Morainic System front (Roadside near center of north edge NE¼ NE¼ NW¼ Sec. 19, T. 11 N., R. 10 E., 3rd P.M., Coles County; Charleston South 7.5-minute Quadrangle).

We are standing on the outer (frontal) slope not only of a large end moraine, the Shelbyville Morainic System, but also on the Wisconsinan Woodfordian moraine that extended the farthest south in our state (note map of Woodfordian Moraines in Pleistocene Glaciations in Illinois in the back). This moraine was formed nearly 22,000 years ago when the glacier front was close to where we are standing. The position of the ice front was stationary for an unknown length of time as new ice laden with rock and soil debris flowed southward to the front to replace ice that was melting away. Melting of the ice released the entrapped debris permitting it to be dumped and stacked at the ice margin. This process continued over many years, eventually building a large end moraine.

This is one of the better locations in this area from which to look out across the Illinoian till plain to the south. We are about half way down the frontal slope of the Shelbyville Morainic System. About 3/4 mile to the north, the crest of the Shelbyville System (Westfield Moraine) has a surface elevation of approximately 730 feet msl. Here the elevation is about 680 feet msl. About 3/4 mile to the south, the surface elevation is about 630 feet or less above msl and the gradient of the slope is much lower. The more gentle slope to the south is underlain by outwash deposits that are partly sand and gravel but not thick enough to be of commercial value at this time.

Later we will look northward toward this locality from Stop 8, two miles to the south. Pick out a couple of prominent landmarks here to facilitate identification of this place from Stop 8.

STOP 7. Discussion of Pleistocene stratigraphy at the Center School Section (East cut bank of West Branch Hurricane Creek, approximately ¼ mile north of field access road NW¼ NW¼ SW¼ Sec. 15, T. 11 N., R. 10 E., 3rd P.M., Coles County; Westfield West 7.5-minute Quadrangle).

The stream-cut east bank of the creek north of the small field affords an excellent opportunity to examine Ice Age deposits from the Illinoian (oldest), Sangamonian, Wisconsinan, and Holocene Stages.

Pleistocene Series

Wisconsinan Stage

Woodfordian Substage

Richland Loess

Modern Soil (Holocene Stage)

Silt - dark grayish-brown, platy, friable silt loam near the top becomes yellowish-brown, massive to weak, blocky, silty clay loam downward; 3.5 feet.

Henry Formation

Sand - dark yellowish-brown, massive, iron- and clay-enriched sandy loam; 0.5 feet

Wedron Formation

Glenburn Till Member

Till - yellowish-brown loam with dark reddish-brown staining on joints; a few clay coatings; weak, blocky structure in top 1.5 feet. Becomes calcareous; soft; weak, moderate to coarse blocky structure and dark gray at base; sand and silt inclusions in upper 6 feet of this unit; lower 6 inches oxidized 14 feet

Sand - gravelly; tan to yellowish-brown; loamy; calcareous; medium to coarse grained; beds 1" to 3" thick; lower 6 inches laminated, firm; contains a few wood fragments; 4.5 feet

Robein Silt

Farmdale Soil

Silty muck - dark brown becomes very dark gray on exposure; soft; massive; wood fragments radiocarbon dated 20,000± 130 years B. P. (before present); 1.5 feet

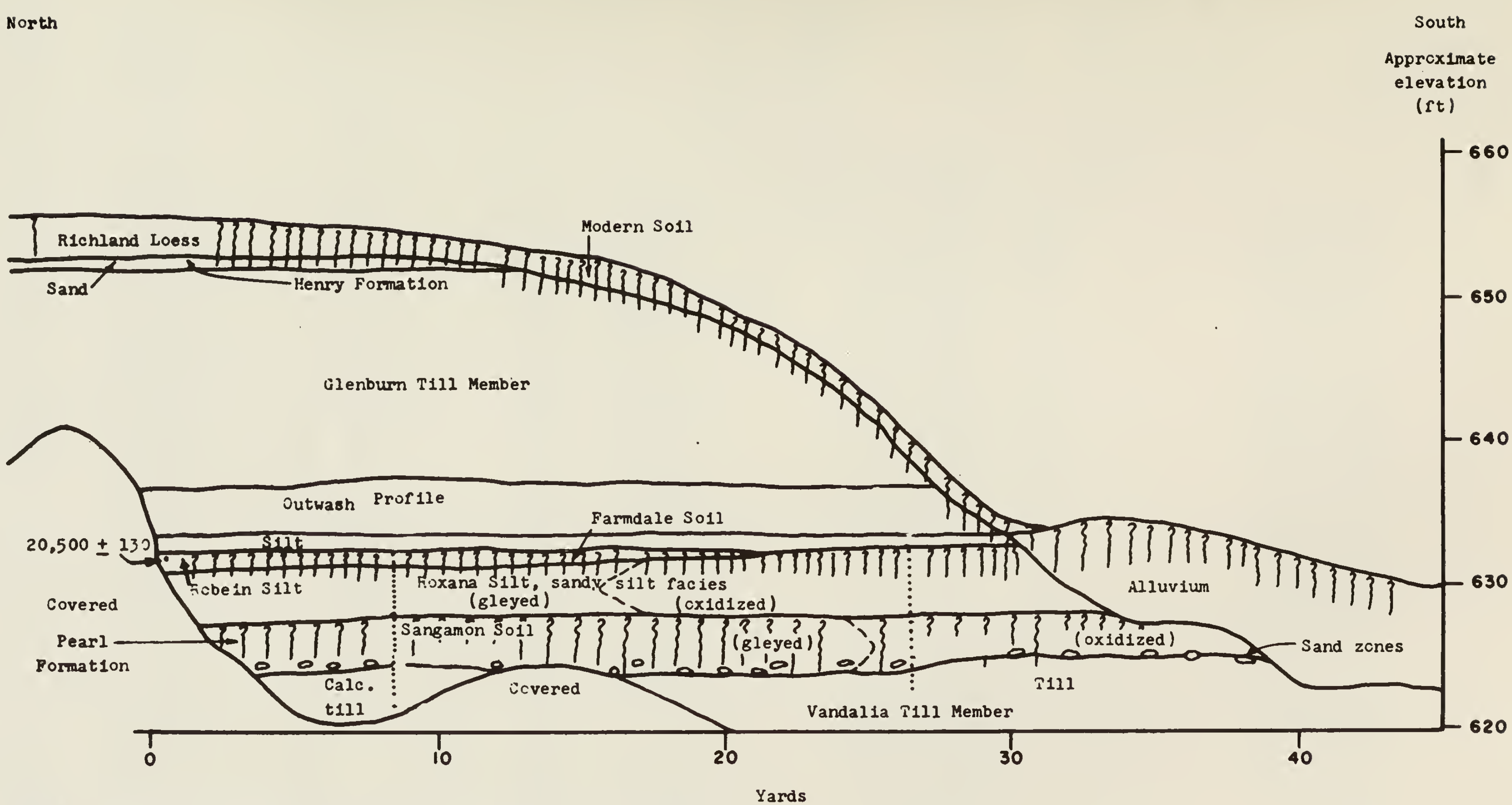


Figure 9. Sketch of the Center School Section (modified from Johnson et al., 1972).

Altonian Substage

Roxana Silt

Sand silt - dark gray loam grading downward to dark gray with few strong brown mottles; common krotovina (animal burrow infillings) filled with dark gray loam; few secondary carbonate concretions; many thin clay coatings; massive to weak platy structure; friable; 3.5 feet

Illinoian Stage

Monican Substage

Pearl Formation

Sangamon Soil (Sangamonian Stage)

Sand - clayey, silty; greenish gray clay loam with few red mottles; few clay coatings; massive; firm; zones of intense olive staining increase toward base of gley; common krotovina filled with loam; concentration of poorly sorted gravel at base; massive to weak blocky structure; 3.6 feet

Glasford Formation

Vandalia Till Member

Till - greenish gray clay loam with few red and olive mottles increasing to nearly 50% of lower part of horizon; thick clay accumulations at base in probable crayfish terminal pocket; firm; massive; 1.9 feet

Till - dark greenish brown loam with prominent yellowish brown stains along joints, few black stains; calcareous; dense hard; 0.5 feet

Total section = 35.0 feet

The Robein Silt pinches out to the south in this exposure. The south part of the exposure is more highly oxidized than is the north part.

The Sangamon Soil is not as well developed here as in other sections in this region.

STOP 8. View of Shelbyville moraine front from the Illinoian till plain (Roadside along south edge SW¼ SW¼ SW¼ SE¼ Sec. 30, T. 11 N., R. 10 E., 3rd P.M., Cumberland County; Toledo 7.5-minute Quadrangle).

We are standing a little more than a mile south of the toe of the Shelbyville moraine front and two miles south of Stop 6. The surface of the Springfield Plain (fig. 1), underlain by Illinoian ground moraine, slopes gently toward us

from about 630 feet msl at the toe of the moraine to about 612 feet msl here. At the intersection of this road with SR 130 just ahead (west) of us 0.3 mile, the elevation is 615 feet msl; one mile south on SR 130 the elevation is 608 feet; and two miles south it is 604 feet. Small, broad, low hills rise above this gentle slope only about 10 feet or so. The Illinoian till plain thus is a generally flat surface with most of the relief in this area due to streams cutting their way into the upland surface. Even immediately after the Illinoian glacier melted away, surface relief in the region probably wasn't much greater than it is now. In addition, the whole region has been subjected to a long interval of erosion after the Illinoian glacier melted, which undoubtedly has further subdued the topographic relief.

As the Shelbyville glacier melted away just to the north, meltwater carried some of the debris from the ice, as well as some from the end moraine, away from the moraine front to form a thin outwash apron sloping southward away from the moraine. The coarsest material was deposited closest to the moraine and the finest material was carried farthest away. In this area, outwash debris unless concentrated along large streams is not economically minable at present. We are standing on some of the finer grained outwash materials into which the modern soil has developed.

STOP 9. Discussion of sand and gravel deposit at the C. and H. Gravel Pit Office (NW¼ NW¼ NE¼ NW¼ Sec. 1, T. 10 N., R. 9 E., 3rd P.M., Cumberland County; Toledo 7.5-minute Quadrangle).

NOTE: You MUST have permission to enter this property.

This operation is the former Greenup Sand and Gravel Pit. C. and H. Gravel also operates the former Urban #2 Pit across the road to the north (SW¼ Sec. 36, T. 11 N., R. 9 E., 3rd P.M., Cumberland County; Toledo 7.5-minute Quadrangle).

This sand and gravel pit initially was a dry pit. The water table (the upper surface of the zone of saturation) was reached after about 30 feet of sand and gravel had been mined. Approximately 30 additional feet of sand and gravel are available for this dredging operation. The deposit consists mainly of fine to coarse sand and some fine gravel. The dredged material is piped to the processing plant where it is washed and screened (sieved) into various size fractions.

Sand products (fine aggregate) are utilized by the local construction industry in portland cement concrete, asphalt cemented pavement, and blacktop surfacing. The gravel (coarse aggregate) is mainly used to construct and maintain gravel roads. Although the gravel contains a large amount of hard igneous and metamorphic rocks, it also contains an abundance of Pennsylvanian-age rock types including sandstone, siltstone, and shale. The latter materials, plus clay balls from the glacial till reduce the overall quality of the gravel, and make it unsuitable for use in portland cement concrete and asphalt cement used for highways constructed according to state standards.

The sand and gravel deposit lies within a narrow band of outwash located on the south, or down-ice, side of the Shelbyville moraine. It may consist of pro-glacial outwash, deposited as the ice sheet advanced southward, and then added to as the moraine was being deposited just to the north. As noted earlier, at many places along the moraine front, the outwash is too thin to be excavated and processed economically. However, here the deposit has a total thickness of nearly 60 feet with only about 5 feet of clayey silt and sand overburden to be stripped away in advance of the dredging operation.

According to Ford (1972?), the thick deposits of sand and gravel here were deposited by streams of glacial meltwater flowing away from the advancing front of the Wisconsinan ice sheet. Several smaller meltwater streams may have converged here to form a larger, master drainage that deposited these thicker sands and gravels. As the ice continued to advance, the glacier eventually overrode the outwash sands and gravels and buried them with a thin layer of ground moraine. A little later, melting increased to a rate faster than the flow of the ice and the glacier front melted back to the position where the Shelbyville Morainic System was deposited.

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PLEISTOCENE GLACIATIONS IN ILLINOIS

Origin of the Glaciers

During the past million years or so, the period of time called the Pleistocene Epoch, most of the northern hemisphere above the 50th parallel has been repeatedly covered by glacial ice. Ice sheets formed in sub-arctic regions four different times and spread outward until they covered the northern parts of Europe and North America. In North America the four glaciations, in order of occurrence from the oldest to the youngest, are called the Nebraskan, Kansan, Illinoian, and Wisconsinan Stages of the Pleistocene Epoch. The limits and times of the ice movement in Illinois are illustrated in the following pages by several figures.

The North American ice sheets developed during periods when the mean annual temperature was perhaps 4° to 7° C (7° to 13° F) cooler than it is now and winter snows did not completely melt during the summers. Because the cooler periods lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused them to flow outward at their margins, often for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Tongues of ice, called lobes, flowed southward from the Canadian centers near Hudson Bay and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch below shows several centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it has been invaded by glaciers from every center.

Effects of Glaciation

Pleistocene glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, for much of what the glaciers wore off the ground was kneaded into the moving ice and carried along, often for hundreds of miles.

The continual floods released by melting ice entrenched new drainageways, deepened old ones, and then partly refilled both with sediments as great quantities of rock and earth were carried beyond the glacier fronts. According to some estimates, the amount of water drawn from the sea and changed into ice during a glaciation was probably enough to lower sea level more than 300 feet below present level. Consequently, the melting of a continental ice sheet provided a tremendous volume of water that eroded and transported sediments.

In most of Illinois, then, glacial and meltwater deposits buried the old rock-ribbed, low, hill-and-valley terrain and created the flatter landforms of our prairies. The mantle of soil material and the deposits of gravel, sand, and clay left by the glaciers over about 90 percent of the state have been of incalculable value to Illinois residents.

Glacial Deposits

The deposits of earth and rock materials moved by a glacier and deposited in the area once covered by the glacier are collectively called drift. Drift that is ice-laid is called till. Water-laid drift is called outwash.

Till is deposited when a glacier melts and the rock material it carries is dropped. Because this sediment is not moved much by water, a till is unsorted, containing particles of different sizes and compositions. It is also unstratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders.

Tills may be deposited as end moraines, the arc-shaped ridges that pile up along the glacier edges where the flowing ice is melting as fast as it moves forward. Till also may be deposited as ground moraines, or till plains, which are gently undulating sheets deposited when the ice front melts back, or retreats. Deposits of till identify areas once covered by glaciers. Northeastern Illinois has many alternating ridges and plains, which are the succession of end moraines and till plains deposited by the Wisconsinan glacier.

Sorted and stratified sediment deposited by water melting from the glacier is called outwash. Outwash is bedded, or layered, because the flow of water that deposited it varied in gradient, volume, velocity, and direction. As a meltwater stream washes the rock materials along, it sorts them by size--the fine sands, silts, and clays are carried farther downstream than the coarser gravels and cobbles. Typical Pleistocene outwash in Illinois is in multilayered beds of clays, silts, sands, and gravels that look much like modern stream deposits.

Outwash deposits are found not only in the area covered by the ice field but sometimes far beyond it. Meltwater streams ran off the top of the glacier, in crevices in the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed in the ice is preserved as a sinuous ridge called an esker. Cone-shaped mounds of coarse outwash, called kames, were formed where meltwater plunged through crevasses in the ice or into ponds along the edge of the glacier.

The finest outwash sediments, the clays and silts, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the sags of the till plains, and some low, moraine-diked till plains. Meltwater streams that entered a lake quickly lost speed and almost immediately dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sand and silts were moved across the lake bottom by wind-generated

currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting and short-lived streams that laid down a broad, flat blanket of outwash that formed an outwash plain. Outwash was also carried away from the glacier in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and were greatly widened and deepened during times of the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as valley trains. Valley trains may be both extensive and thick deposits. For instance, the long valley train of the Mississippi Valley is locally as much as 200 feet thick.

Loess and Soils

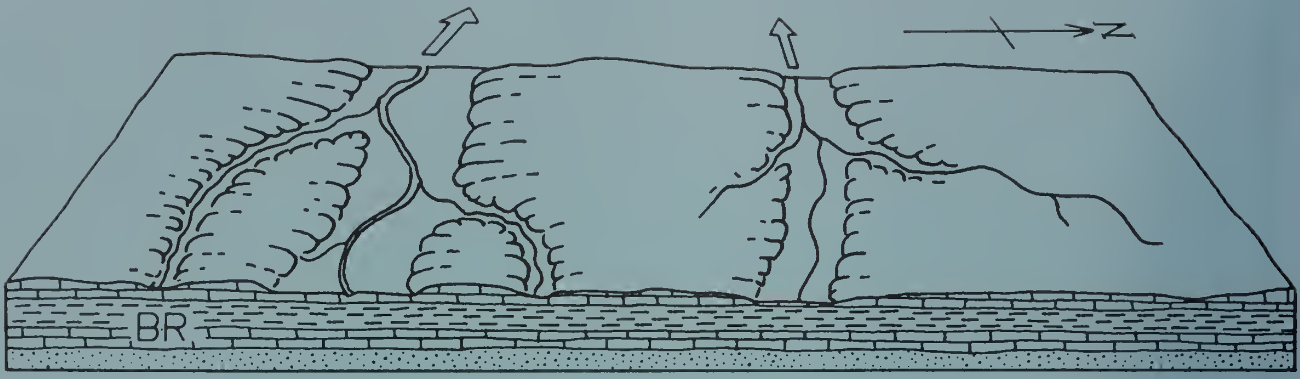
One of the most widespread sediments resulting from glaciation was carried not by ice or water but by wind. Loess is the name given to such deposits of windblown silt and clay. The silt was blown from the valley trains on the floodplains. Most loess deposition occurred in the fall and winter seasons when low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. During Pleistocene time, as now, west winds prevailed, and the loess deposits are thickest on the east sides of the source valleys. The loess thins rapidly away from the valleys but extends over almost all the state.

Each Pleistocene glaciation was followed by an interglacial stage that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the Pleistocene deposits and altered their composition, color, and texture. Such soils were generally destroyed by later glacial advances, but those that survive serve as keys to the identity of the beds and are evidence of the passage of a long interval of time.

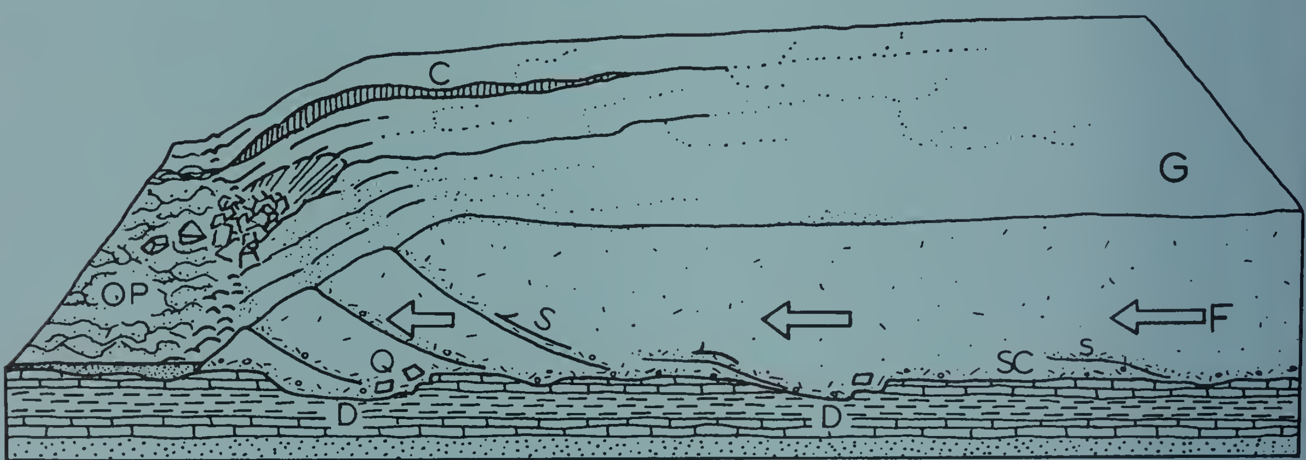
Glaciation in a Small Illinois Region

The following diagrams show how a continental ice sheet might have looked as it moved across a small region in Illinois. They illustrate how it could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions and also the present-day mountain glaciers and polar ice caps.

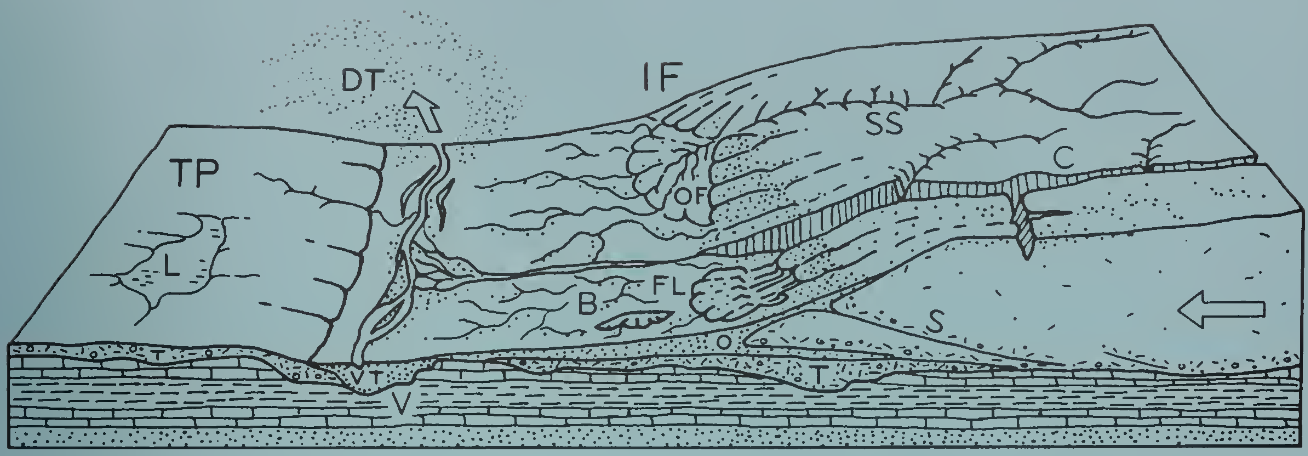
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated--layers of material are drawn thicker and landforms higher than they ought to be so that they can be easily seen.



1. <u>The Region Before Glaciation</u> - Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks--layers of sandstone ( ), limestone ( ), and shale ( ). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



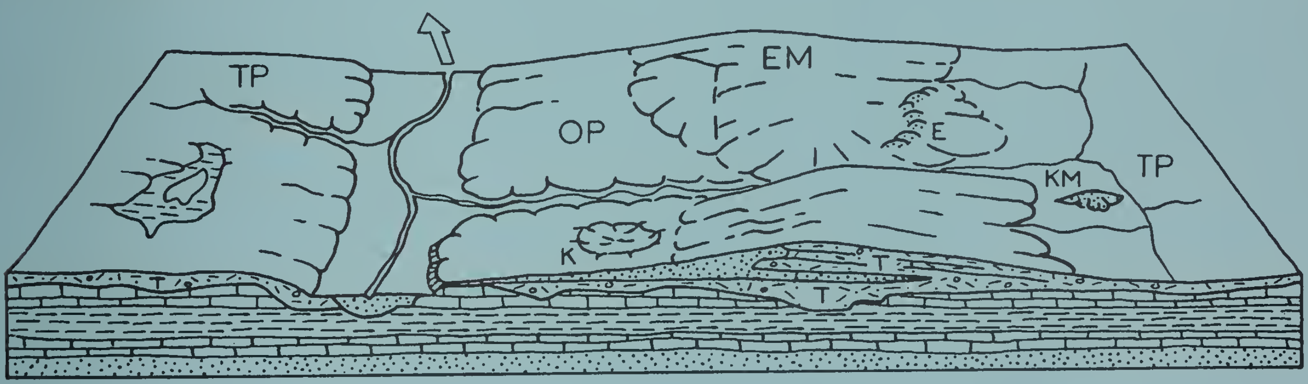
2. <u>The Glacier Advances Southward</u> - As the glacier (G) spreads out from its snowfield, it scours (SC) the soil and rock surface and quarries (Q)--pushes and plucks up--chunks of bedrock. These materials are mixed into the ice and make up the glacier's "load." Where roughnesses in the terrain slow or stop flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing mixes the load very thoroughly. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before the ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plain (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5000 or so feet thick , except near its margin. Its ice front advances perhaps as much as a third of a mile per year.



3. <u>The Glacier Deposits an End Moraine</u> - After the glacier advanced across the area, the climate warmed and the ice began to melt as fast as it advanced. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is depositing an end moraine.

As the top of the glacier melts, some of the sediment that was mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A superglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) was left as a till layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remained a low spot in the terrain. As soon as its ice cover melted, meltwater drained down the valley, cutting it deeper. Later, outwash partly refilled the valley--the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles.



4. <u>The Region after Glaciation</u> - The climate has warmed even more, the whole ice sheet has melted, and the glaciation has ended. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream goes through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

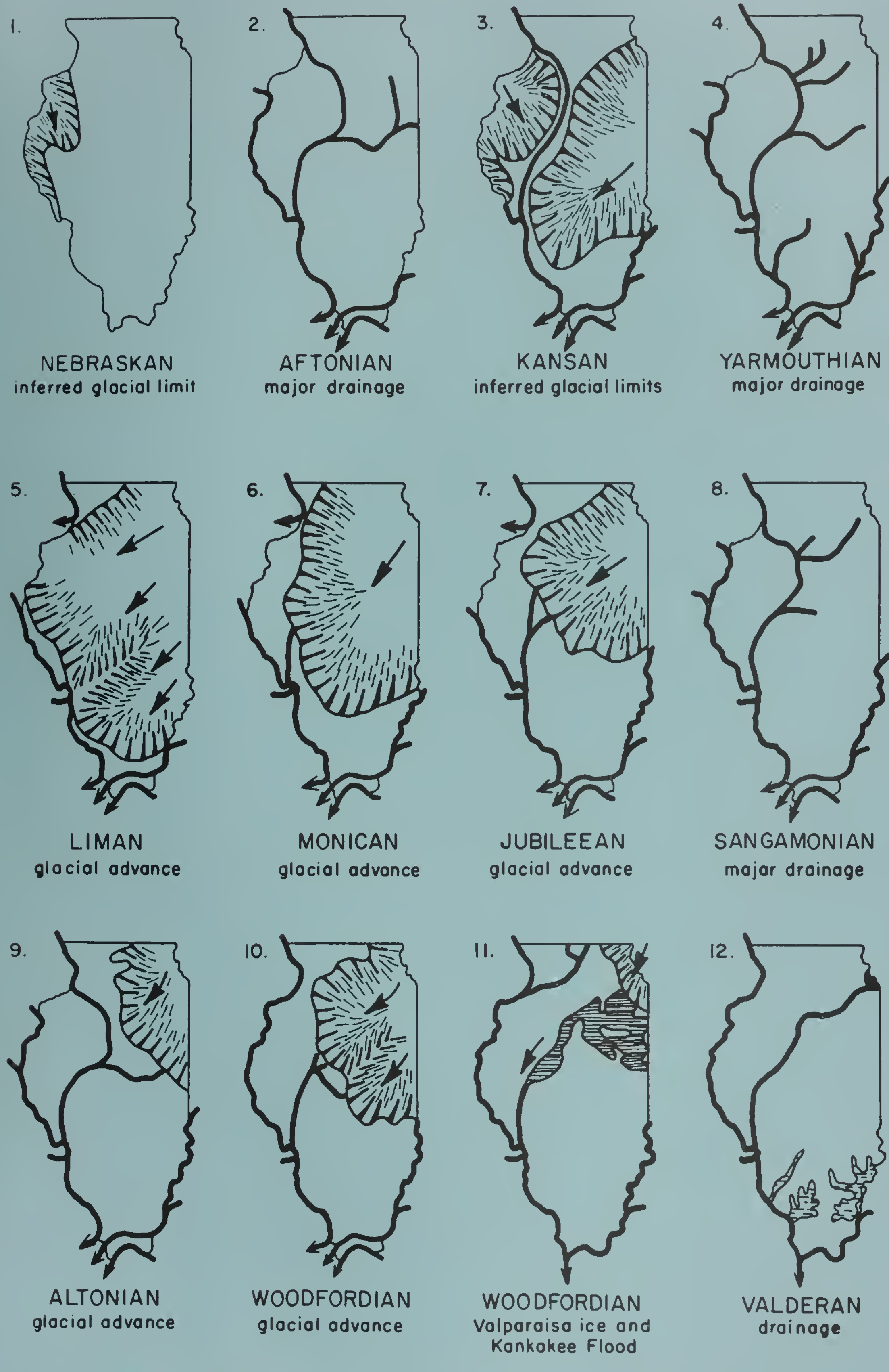
Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left by the ice block's melting has made a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.

TIME TABLE OF PLEISTOCENE GLACIATION

STAGE	SUBSTAGE	NATURE OF DEPOSITS	SPECIAL FEATURES
HOLOCENE	Years Before Present	Soil, youthful profile of weathering, lake and river deposits, dunes, peat	
	7,000		
WISCONSINAN (4th glacial)	Valderan	Outwash, lake deposits	Outwash along Mississippi Valley
	11,000		
	Twocreekan	Peat and alluvium	Ice withdrawal, erosion
	12,500		
	Woodfordian	Drift, loess, dunes, lake deposits	Glaciation; building of many moraines as far south as Shelbyville; extensive valley trains, outwash plains, and lakes
	22,000		
	Farmdalian	Soil, silt, and peat	Ice withdrawal, weathering, and erosion
	28,000		
	Altonian	Drift, loess	Glaciation in northern Illinois, valley trains along major rivers
	75,000		
SANGAMONIAN (3rd interglacial)		Soil, mature profile of weathering	
	175,000		
ILLINOIAN (3rd glacial)	Jubileean	Drift, loess	Glaciers from northeast at maximum reached Mississippi River and nearly to southern tip of Illinois
	Monican	Drift, loess	
	Liman	Drift, loess	
	300,000		
YARMOUTHIAN (2nd interglacial)		Soil, mature profile of weathering	
	600,000		
KANSAN (2nd glacial)		Drift, loess	Glaciers from northeast and northwest covered much of state
	700,000		
AFTONIAN (1st interglacial)		Soil, mature profile of weathering	
	900,000		
NEBRASKAN (1st glacial)		Drift	Glaciers from northwest invaded western Illinois
	1,200,000 or more		

(Illinois State Geological Survey, 1973)

SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



(From Willman and Frye, "Pleistocene Stratigraphy of Illinois," ISGS Bull. 94, fig. 5, 1970.)

WOODFORDIAN MORAINES
H. B. Willman and John C. Frye
1970
Boundary of Woodfordian glaciation
WOODFORDIAN
Le Roy Named moraine
ILLIANA Named morainic system
Intermorainal area
0 10 20 30 Miles
0 20 40 Kilometers
VALPARAISO
BLOOMINGTON
MARSEILLES
LAKE BORDER
ILLIANA
SHELBYVILLE (Undifferentiated)
BLOOMINGTON (Undifferentiated)

ILLINOIS STATE GEOLOGICAL SURVEY
Urbana, Illinois 61801

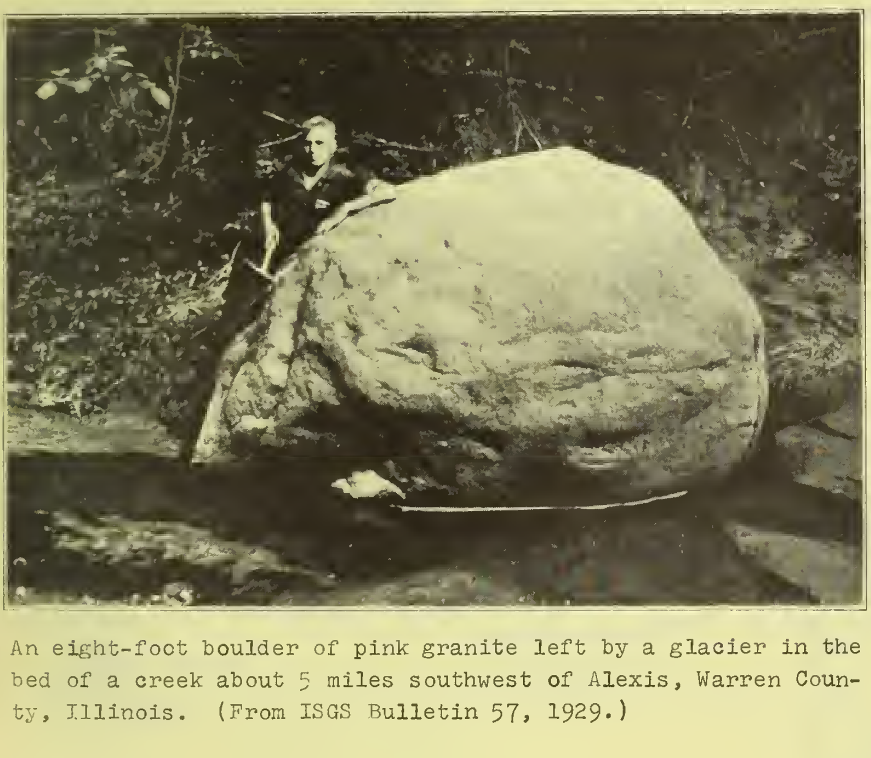
GEOGRAM 2
October 1974

ERRATICS ARE ERRATIC

Myrna M. Killey

You may have seen them scattered here and there in Illinois—boulders, some large, some small, lying alone or with a few companions in the corner of a field, at the edge of a road, in someone's yard, or perhaps on a courthouse lawn or schoolyard. Many of them seem out of place, like rough, alien monuments in the stoneless, grassy knolls and prairies of our state. Some—the colorful and glittering granites, banded gneisses, and other intricately veined and streaked igneous and metamorphic rocks--are indeed foreign rocks, for they came from Canada and the states north of us. Others—gray and tan sedimentary rocks—are native rocks and may be no more than a few miles from their place of origin. All of these rocks are glacial boulders that were moved to their present sites by massive ice sheets that flowed across our state. If these boulders are unlike the rocks in the quarries and outcrops in the region where they are found, they are called erratics.

The continental glaciers of the Great Ice Age scoured and scraped the land surface as they advanced, pushing up chunks of bedrock and grinding them against each other or along the ground surface as the rock-laden ice sheets pushed southward. Hundreds of miles of such grinding, even on such hard rocks as granite, eventually rounded off the sharp edges of these passengers in the ice until they became the rounded, irregular boulders we see today. Although we do not know the precise manner in which erratics reached their present isolated sites, many were probably dropped directly from the melting front of a glacier. Others may have been rafted to their present resting places by icebergs on ancient lakes or on the floodwaters of some long-vanished stream as it poured from a glacier. Still others, buried in the glacial deposits, could have worked their way up to the land surface as the surrounding loose soil repeatedly froze and thawed. When the freezing ground expands, pieces of rock tend to be pushed upward, where they are more easily reached by the farmer's plow and also more likely to be exposed by erosion.



An eight-foot boulder of pink granite left by a glacier in the bed of a creek about 5 miles southwest of Alexis, Warren County, Illinois. (From ISGS Bulletin 57, 1929.)

Generally speaking, erratics found northeast of a line drawn from Freeport in Stephenson County, southward through Peoria, and then southeastward through Shelbyville to Marshall at the east edge of the state were brought in by the last glacier to enter Illinois. This glaciation, called the Wisconsinan, spread southwestward into Illinois from a center in eastern Canada, reaching our state about 75,000 years ago and (after repeated advances and retreats of the ice margin) melting from the state about 12,500 years ago. Erratics to the west or south of the great arc outlined above were brought in by a much older glacier, the Illinoian, which spread over most of the state about 300,000 to 175,000 years ago. Some erratics were brought in by even older glaciers that came from the northwest.

You may be able to locate some erratics in your neighborhood. Sometimes it is possible to tell where the rock originally came from by determining the kind of rock it is. A large boulder of granite, gneiss, or other igneous or metamorphic rock may have come from the Canadian Shield, a vast area in central and eastern Canada where rocks of Precambrian age (more than 600 million years old) are exposed at the surface. Some erratics containing flecks of copper were probably transported here from the "Copper Range" of the upper peninsula of Michigan. Large pieces of copper have been found in glacial deposits of central and northern Illinois. Light gray to white quartzite boulders with beautiful, rounded pebbles of red jasper came from a very small outcrop area near Bruce Mines, Ontario, Canada. Purplish pieces of quartzite, some of them banded, probably originated in the Baraboo Range of central Wisconsin. Most interesting of all are the few large boulders of Canadian tillite. Tillite is lithified (hardened into rock) glacial till deposited by a Precambrian glacier many millions of years older than the ones that invaded our state a mere few thousand years ago. Glacial till is an unsorted and unlayered mixture of clay, sand, gravel, and boulders that vary widely in size and shape. Tillite is a gray to greenish gray rock containing a mixture of grains of different sizes and scattered pebbles of various types and sizes.

Many erratics are of notable size and beauty, and in parts of Illinois they are commonly used in landscaping. Some are used as monuments in courthouse squares, in parks, or along highways. Many are marked with metal plaques to indicate an interesting historical spot or event. Keep an eye out for erratics. There may be some of these glacial strangers in your neighborhood that would be interesting to know.

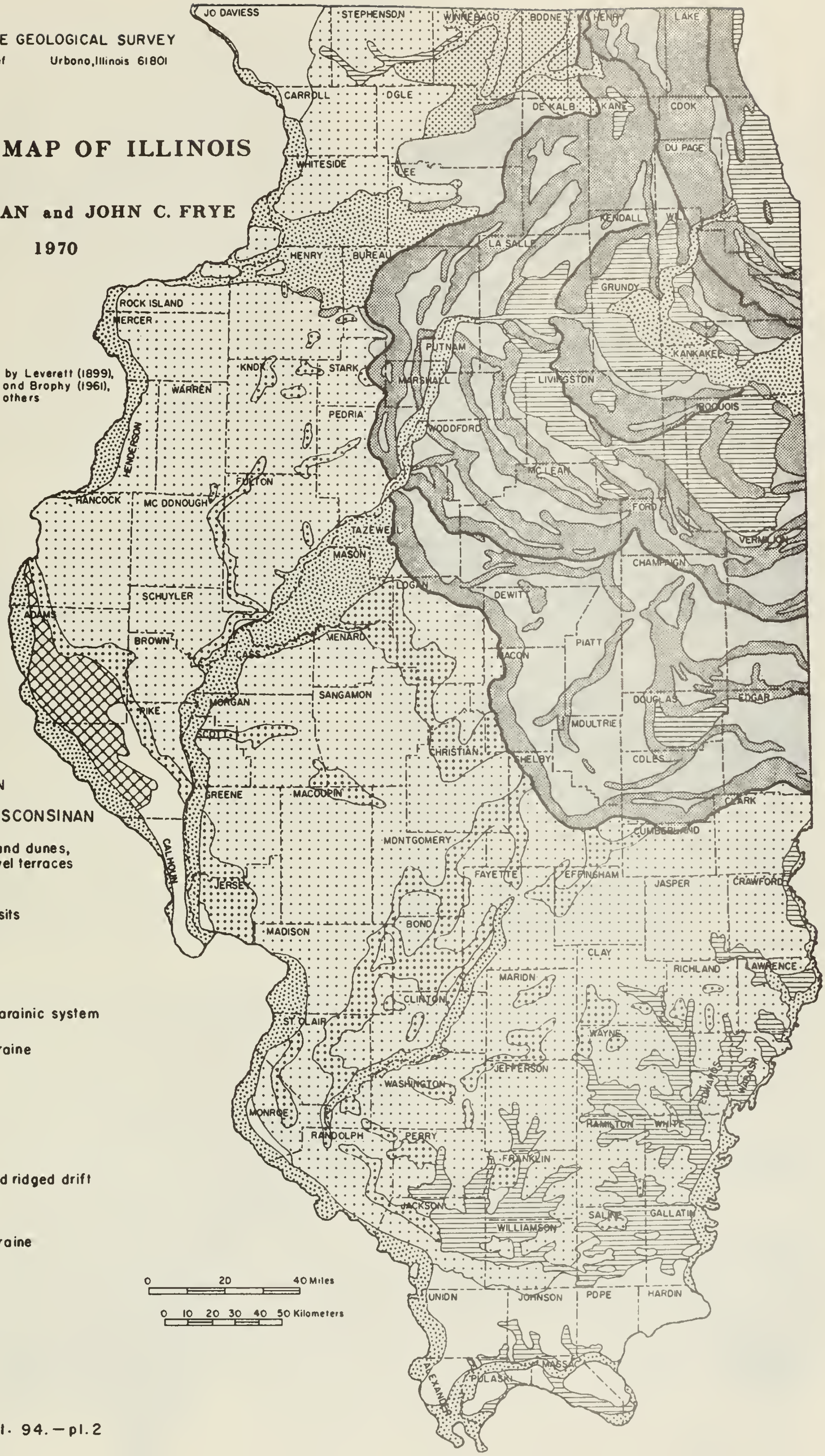
ILLINOIS STATE GEOLOGICAL SURVEY
John C. Frye, Chief Urbana, Illinois 61801

GLACIAL MAP OF ILLINOIS

H.B. WILLMAN and JOHN C. FRYE

1970

Modified from maps by Leverett (1899), Ekblaw (1959), Leighton and Brophy (1961), Willman et al. (1967), and others



EXPLANATION

HOLOCENE AND WISCONSINAN
- Alluvium, sand dunes, and gravel terraces

WISCONSINAN
- Lake deposits

WOODFORDIAN
- Moraine
- Front of morainic system
- Groundmoraine

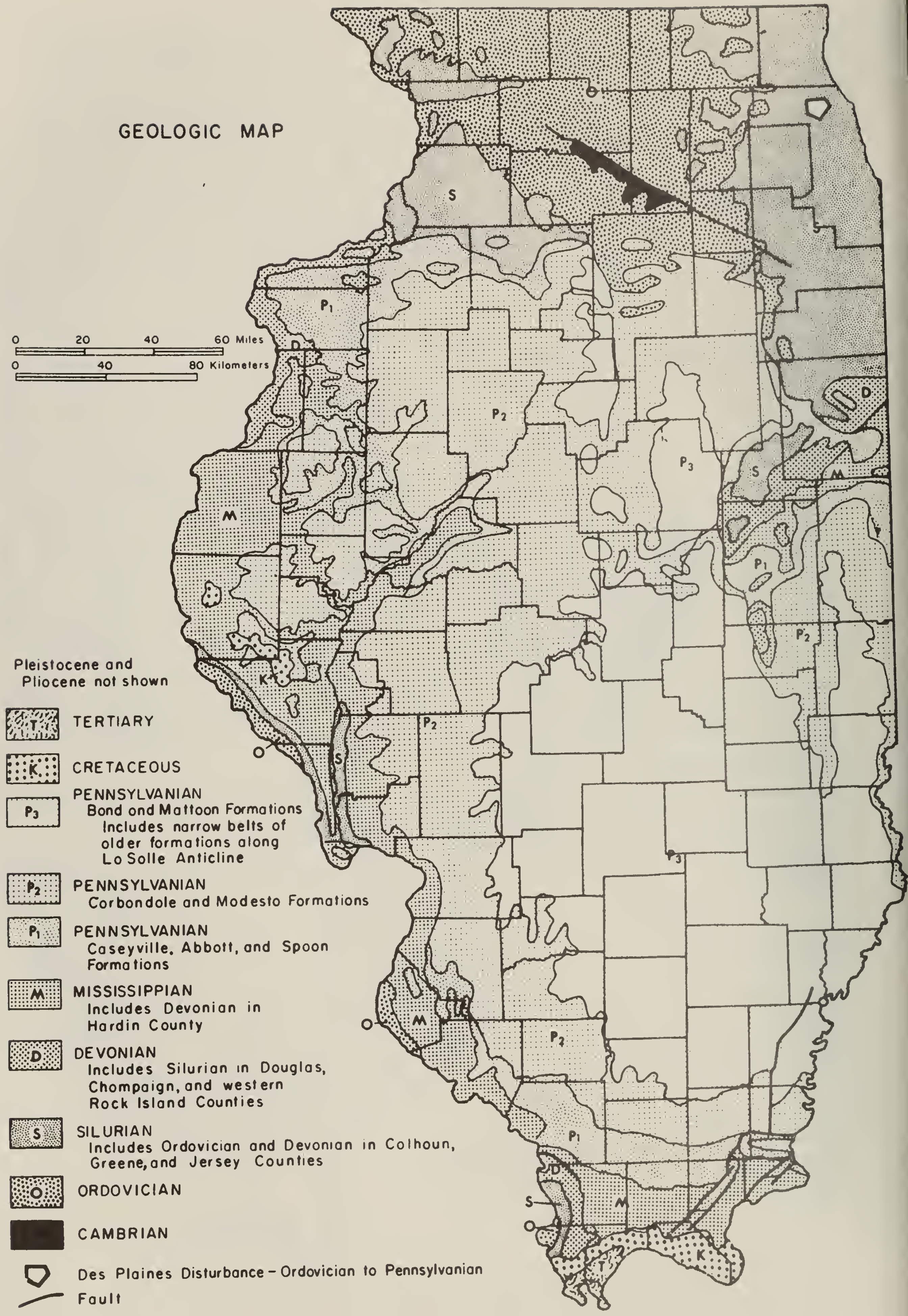
ALTONIAN
- Till plain

ILLINOIAN
- Moraine and ridged drift
- Groundmoraine

KANSAN
- Till plain

DRIFTLESS

Modified from Bull. 94.—pl. 2


GEOLOGIC MAP
0 20 40 60 Miles
0 40 80 Kilometers
Pleistocene and Pliocene not shown
T TERTIARY
K CRETACEOUS
P3 PENNSYLVANIAN Bond and Mattoon Formations Includes narrow belts of older formations along La Salle Anticline
P2 PENNSYLVANIAN Carbondale and Modesto Formations
P1 PENNSYLVANIAN Caseyville, Abbott, and Spoon Formations
M MISSISSIPPIAN Includes Devonian in Hardin County
D DEVONIAN Includes Silurian in Douglas, Champaign, and western Rock Island Counties
S SILURIAN Includes Ordovician and Devonian in Calhoun, Greene, and Jersey Counties
O ORDOVICIAN
CAMBRIAN
Des Plaines Disturbance – Ordovician to Pennsylvanian
Fault

DEPOSITIONAL HISTORY OF THE PENNSYLVANIAN ROCKS

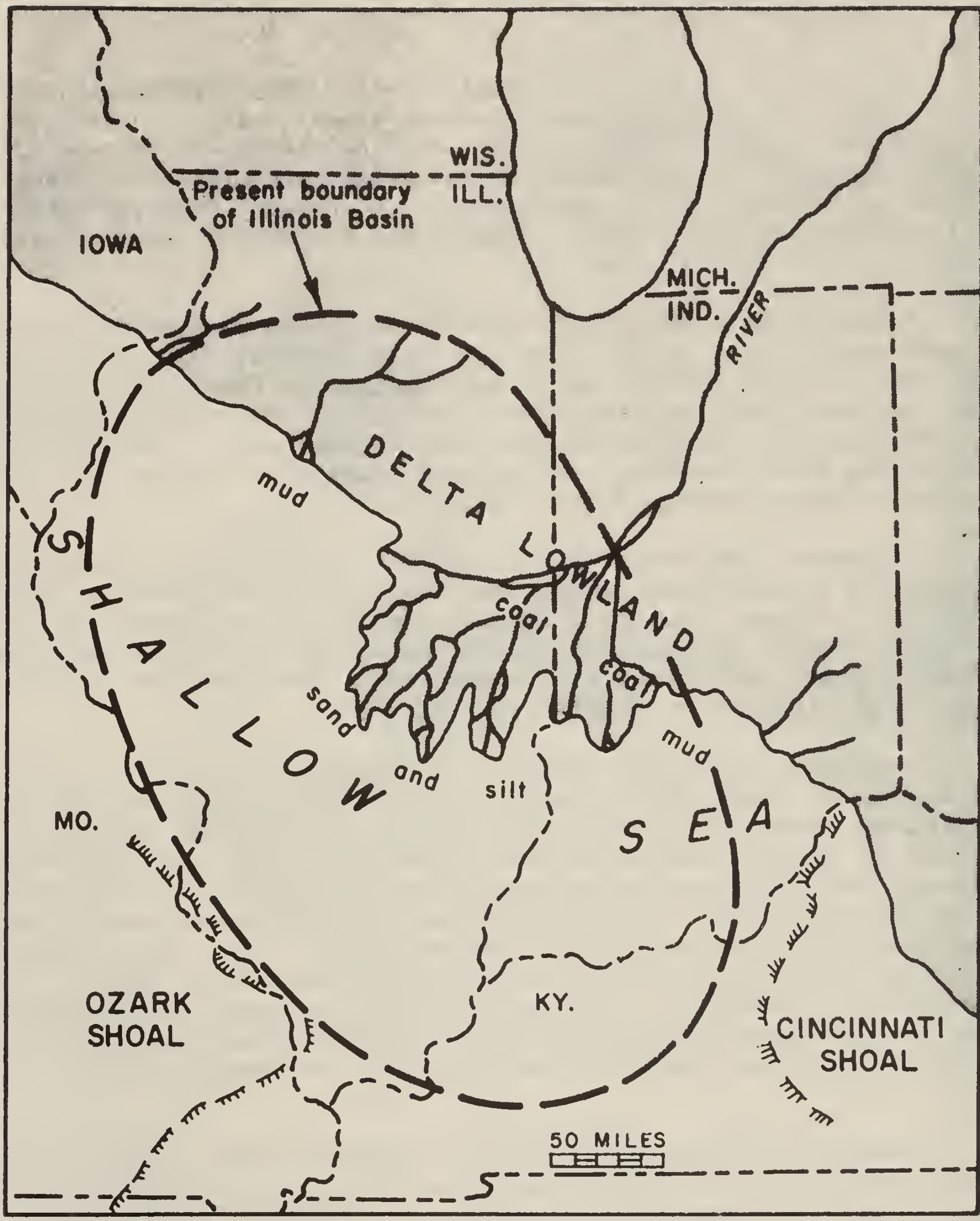
At the close of the Mississippian Period, about 310 million years ago, the Mississippian sea withdrew from the Midcontinent region. A long interval of erosion took place early in Pennsylvanian time and removed hundreds of feet of the pre-Pennsylvanian strata, completely stripping them away and cutting into older rocks over large areas of the Midwest. An ancient river system cut deep channels into the bedrock surface. Erosion was interrupted by the invasion of the Morrowan (early Pennsylvanian) sea.

Depositional conditions in the Illinois Basin during the Pennsylvanian Period were somewhat similar to those that existed during Chesterian (late Mississippian) time. A river system flowed southwestward across a swampy lowland, carrying mud and sand from highlands in the northeast. A great delta was built out into the shallow sea (see paleogeography map on next page). As the lowland stood only a few feet above sea level, only slight changes in relative sea level caused great shifts in the position of the shoreline.

Throughout Pennsylvanian time the Illinois Basin continued to subside while the delta front shifted owing to worldwide sea level changes, intermittent subsidence of the basin, and variations in the amounts of sediment carried seaward from the land. These alternations between marine and nonmarine conditions were more frequent than those during pre-Pennsylvanian time, and they produced striking lithologic variations in the Pennsylvanian rocks.

Conditions at various places on the shallow sea floor favored the deposition of sandstone, limestone, or shale. Sandstone was deposited near the mouths of distributary channels. These sands were reworked by waves and spread as thin sheets near the shore. The shales were deposited in quiet-water areas—in delta bays between distributaries, in lagoons behind barrier bars, and in deeper water beyond the nearshore zone of sand deposition. Most sediments now recognized as limestones, which are formed from the accumulation of limey parts of plants and animals, were laid down in areas where only minor amounts of sand and mud were being deposited. Therefore, the areas of sandstone, shale, and limestone deposition continually changed as the position of the shoreline changed and as the delta distributaries extended seaward or shifted their positions laterally along the shore.

Nonmarine sandstones, shales, and limestones were deposited on the deltaic lowland bordering the sea. The nonmarine sandstones were deposited in distributary channels, in river channels, and on the broad floodplains of the rivers. Some sand bodies, 100 or more feet thick, were deposited in channels that cut through many of the underlying rock units. The shales were deposited mainly on floodplains. Freshwater limestones and some shales were deposited locally in fresh-water lakes and swamps. The coals were formed by the accumulation of plant material, usually where it grew, beneath the quiet waters of extensive swamps that prevailed for long intervals on the emergent delta lowland. Lush forest vegetation, which thrived in the warm, moist Pennsylvanian climate, covered the region. The origin of the underclays beneath the coals is not precisely known, but they were probably deposited in the swamps as slackwater muds before the formation of the coals. Many underclays contain plant roots and rootlets that appear to be in their original places. The formation of coal marked the end of the nonmarine portion of the depositional cycle, for resubmergence of the borderlands by the sea interrupted nonmarine deposition, and marine sediments were then laid down over the coal.



Paleogeography of Illinois-Indiana region during Pennsylvanian time. The diagram shows the Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.

Pennsylvanian Cyclothems

Because of the extremely varied environmental conditions under which they formed, the Pennsylvanian strata exhibit extraordinary variations in thickness and composition, both laterally and vertically. Individual sedimentary units are often only a few inches thick and rarely exceed 30 feet thick. Sandstones and shales commonly grade laterally into each other, and shales sometimes interfinger and grade into limestones and coals. The underclays, coals, black shales, and

limestones, however, display remarkable lateral continuity for such thin units (usually only a few feet thick). Coal seams have been traced in mines, outcrops, and subsurface drill records over areas comprising several states.

The rapid and frequent changes in depositional environments during Pennsylvanian time produced regular or cyclical alternations of sandstone, shale, limestone, and coal in response to the shifting front of the delta lowland. Each series of alternations, called a cyclothem, consists of several marine and nonmarine rock units that record a complete cycle of marine invasion and retreat. Geologists have determined, after extensive studies of the Pennsylvanian strata in the Midwest, that an ideally complete cyclothem consists of 10 sedimentary units. The chart on the next page shows the arrangement. Approximately 50 cyclothems have been described in the Illinois Basin, but only a few contain all 10 units. Usually one or more are missing because conditions of deposition were more varied than indicated by the ideal cyclothem. However, the order of units in each cyclothem is almost always the same. A typical cyclothem includes a basal sandstone overlain by an underclay, coal, black sheety shale, marine limestone, and gray marine shale. In general, the sandstone-underclay-coal portion (the lower 5 units) of each cyclothem is nonmarine and was deposited on the coastal lowlands from which the sea had withdrawn. However, some of the sandstones are entirely or partly marine. The units above the coal are marine sediments and were deposited when the sea advanced over the delta lowland.

Origin of Coal

It is generally accepted that the Pennsylvanian coals originated by the accumulation of vegetable matter, usually in place, beneath the waters of extensive, shallow, fresh-to-brackish swamps. They represent the last-formed deposits of the nonmarine portions of the cyclothems. The swamps occupied vast areas of the deltaic coastal lowland, which bordered the shallow Pennsylvanian sea. A luxuriant growth of forest plants, many quite different from the plants of today, flourished in the warm Pennsylvanian climate. Today's common deciduous trees were not present, and the flowering plants had not yet evolved. Instead, the jungle-like forests were dominated by giant ancestors of present-day club mosses, horsetails, ferns, conifers, and cycads. The undergrowth also was well developed, consisting of many ferns, fernlike plants, and small club mosses. Most of the plant fossils found in the coals and associated sedimentary rocks show no annual growth rings, suggesting rapid growth rates and lack of seasonal variations in the climate. Many of the Pennsylvanian plants, such as the seed ferns, eventually became extinct.

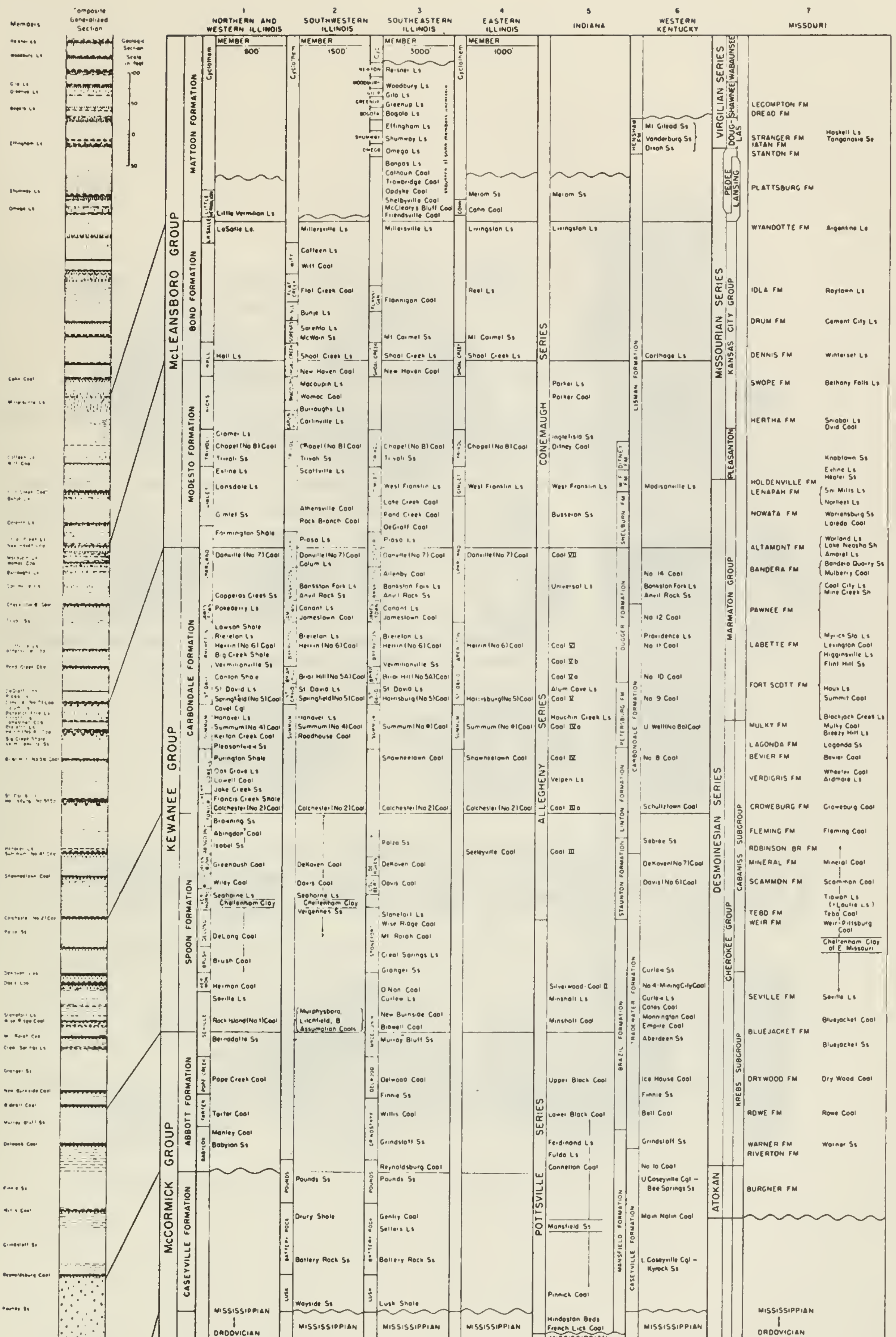
Plant debris from the rapidly growing swamp forests—leaves, twigs, branches, and logs—accumulated as thick mats of peat on the floors of the swamps. Normally, vegetable matter rapidly decays by oxidation, forming water, nitrogen, and carbon dioxide. However, the cover of swamp water, which was probably stagnant and low in oxygen, prevented the complete oxidation and decay of the peat deposits.

The periodic invasions of the Pennsylvanian sea across the coastal swamps killed the Pennsylvanian forests and initiated marine conditions of deposition. The peat deposits were buried by marine sediments. Following burial, the peat deposits were gradually transformed into coal by slow chemical and physical changes in which pressure (compaction by the enormous weight of overlying sedimentary layers), heat (also due to deep burial), and time were the most important factors. Water and volatile substances (nitrogen, hydrogen, and oxygen) were slowly driven off during the coalification process, and the peat deposits were changed into coal.

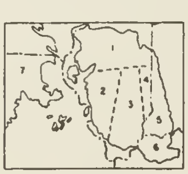
Coals have been classified by ranks that are based on the degree of coalification. The commonly recognized coals, in order of increasing rank, are (1) brown coal or lignite, (2) sub-bituminous, (3) bituminous, (4) semibituminous, (5) semianthracite, and (6) anthracite. Each increase in rank is characterized by larger amounts of fixed carbon and smaller amounts of oxygen and other volatiles. Hardness of coal also increases with increasing rank. All Illinois coals are classified as bituminous.

Underclays occur beneath most of the coals in Illinois. Because underclays are generally unstratified (unlayered), are leached to a bleached appearance, and generally contain plant roots, many geologists consider that they represent the ancient soils on which the coal-forming plants grew.

The exact origin of the carbonaceous black shales that occur above many coals is uncertain. The black shales probably are deposits formed under restricted marine (lagoonal) conditions during the initial part of the invasion cycle, when the region was partially closed off from the open sea. In any case, they were deposited in quiet-water areas where very fine, iron-rich muds and finely divided plant debris were washed in from the land. The high organic content of the black shales is also in part due to the carbonaceous remains of plants and animals that lived in the lagoons. Most of the fossils represent planktonic (floating) and nektonic (swimming) forms—not benthonic (bottom dwelling) forms. The depauperate (dwarf) fossil forms sometimes found in black shales formerly were thought to have been forms that were stunted by toxic conditions in the sulfide-rich, oxygen-deficient waters of the lagoons. However, study has shown that the "depauperate" fauna consists mostly of normal-size individuals of species that never grew any larger.



ROCK STRATIGRAPHIC
AND
CYCLICAL CLASSIFICATIONS
OF THE
PENNSYLVANIAN STRATA OF ILLINOIS



LOCATION MAP

10 Shale, gray, sandy at top; contains marine fossils and ironstone concretions, especially in lower part.

9 Limestone; contains marine fossils.

8 Shale, black, hard, laminated; contains large spheroidal concretions and marine fossils.

7 Limestone; contains marine fossils.

6 Shale, gray; pyritic nodules and ironstone concretions common at base; plant fossils locally common at base; marine fossils rare.

5 Coal; locally contains clay or shale partings.

4 Underclay, mostly medium to light gray but dark gray at top; upper part noncalcareous, lower part calcareous.

3 Limestone, argillaceous; occurs in nodules or discontinuous beds; usually nonfossiliferous.

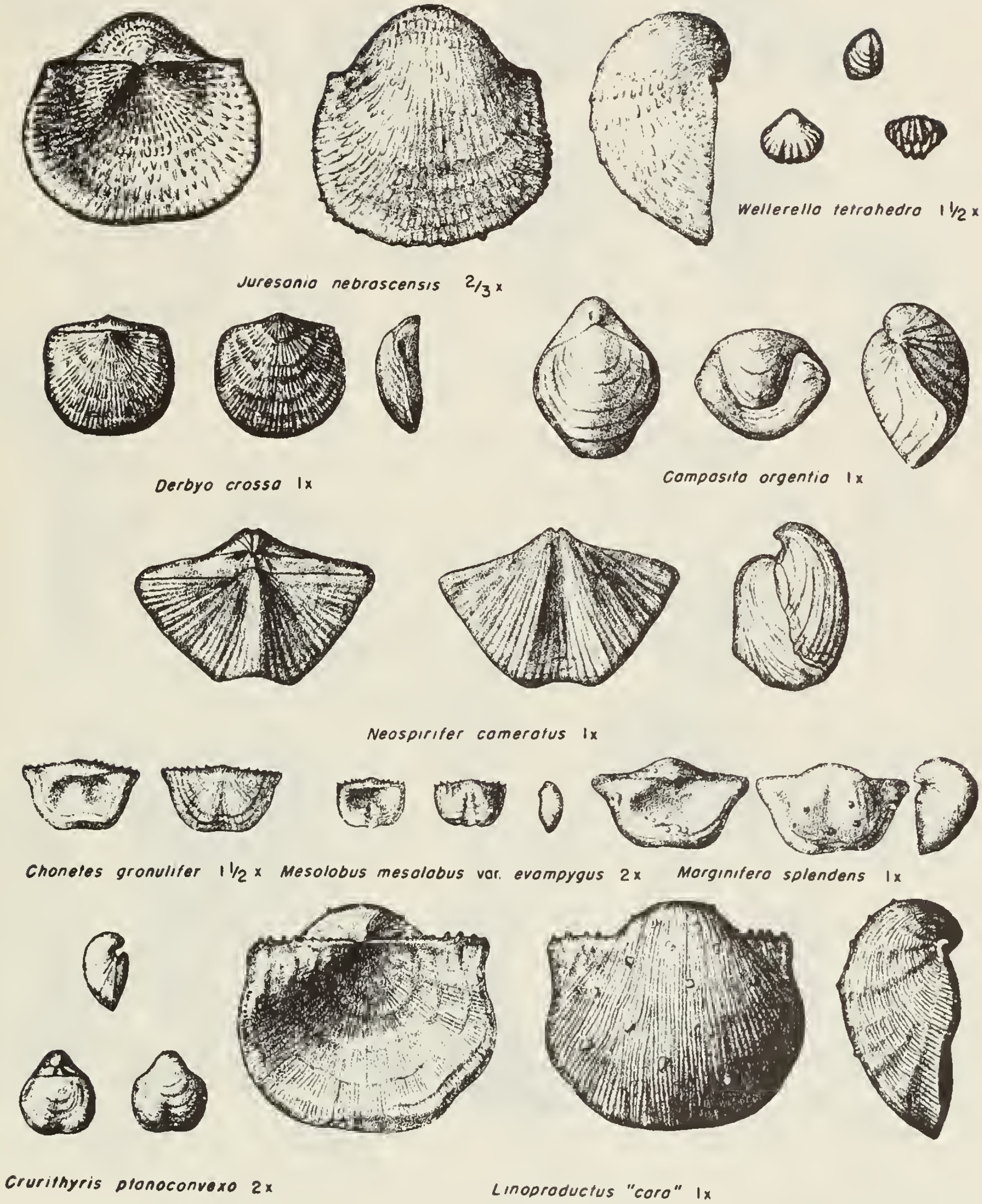
2 Shale, gray, sandy.

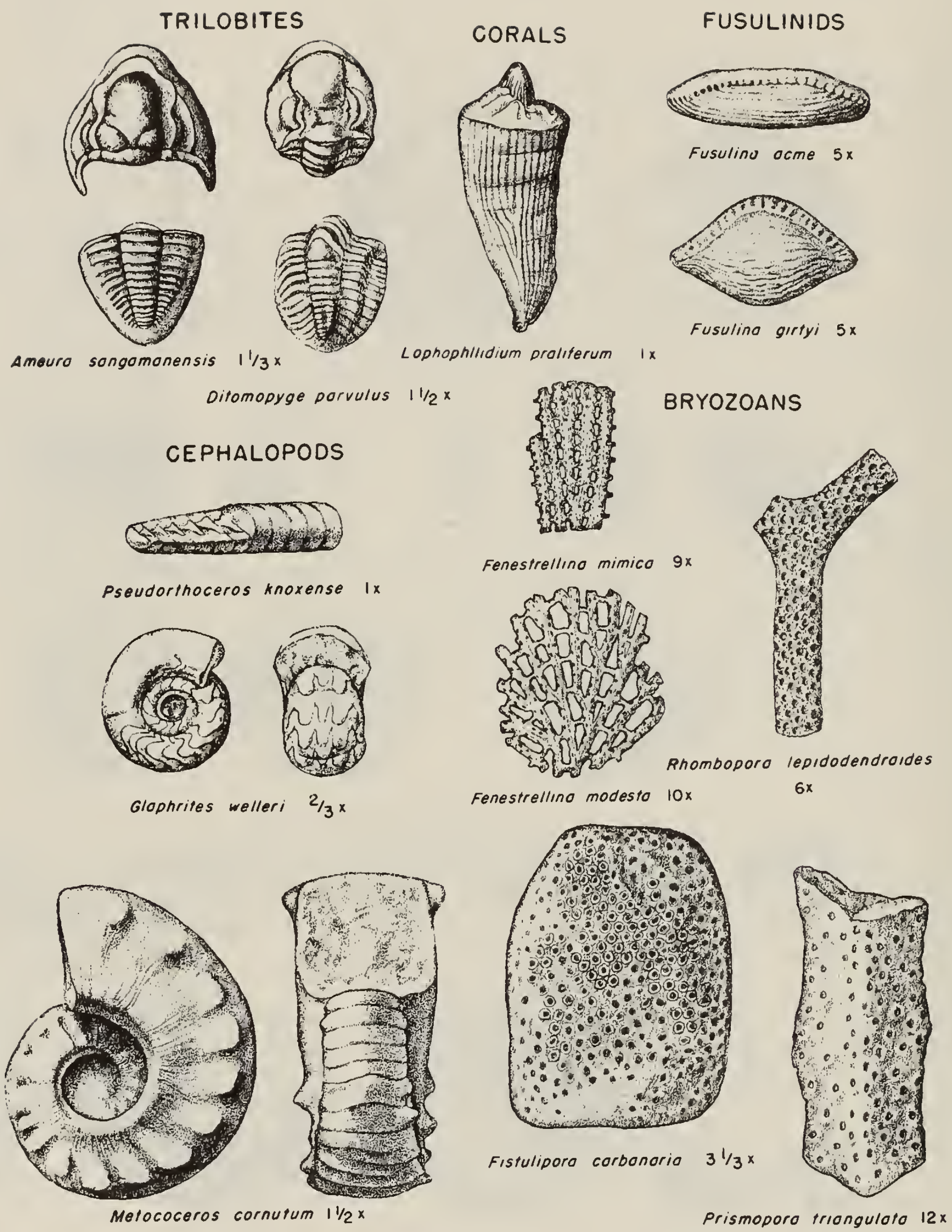
1 Sandstone, fine grained, micaceous, and siltstone, argillaceous; varies from massive to thin bedded; usually has an uneven lower surface.

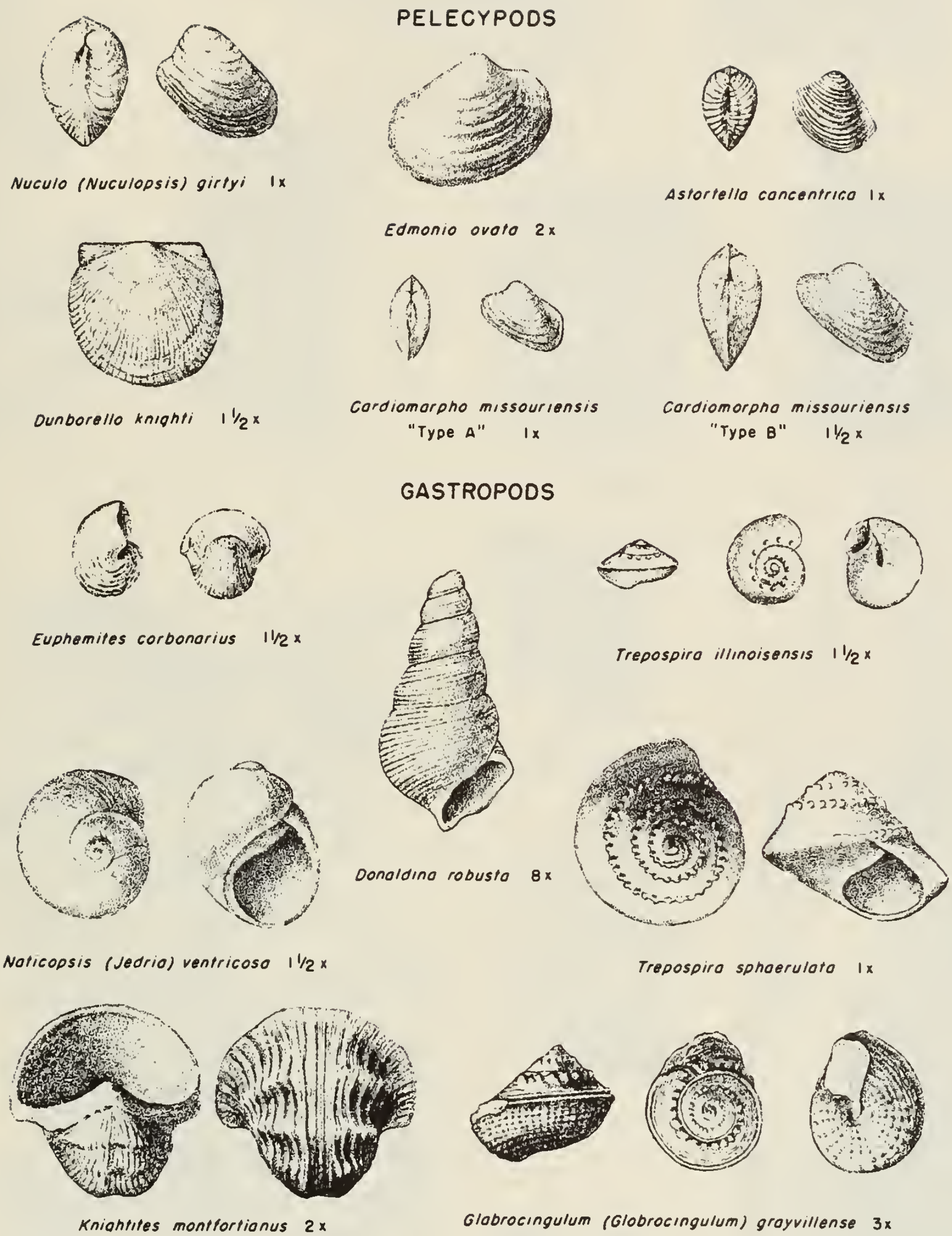
AN IDEALLY COMPLETE CYCLOTHEM

(Reprinted from Fig. 42, Bulletin No. 66, Geology and Mineral Resources of the Marseilles, Ottawa, and Streator Quadrangles, by H. B. Willman and J. Norman Payne)

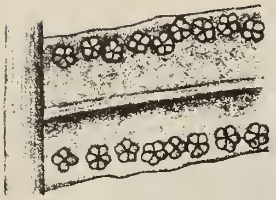
BRACHIOPODS




TRILOBITES
CORALS
FUSULINIDS
Fusulina acme 5x
Fusulina girtyi 5x
Ameura sangamanensis 1 1/3 x
Lophophllidium proliferum 1x
Ditomopyge parvulus 1 1/2 x
BRYOZOANS
CEPHALOPODS
Pseudorthoceros knoxense 1x
Fenestrellina mimica 9x
Rhombopora lepidodendroides 6x
Glaphrites welleri 2/3 x
Fenestrellina modesta 10x
Metacoceras cornutum 1 1/2 x
Fistulipora carbonaria 3 1/3 x
Prismopora triangulata 12x

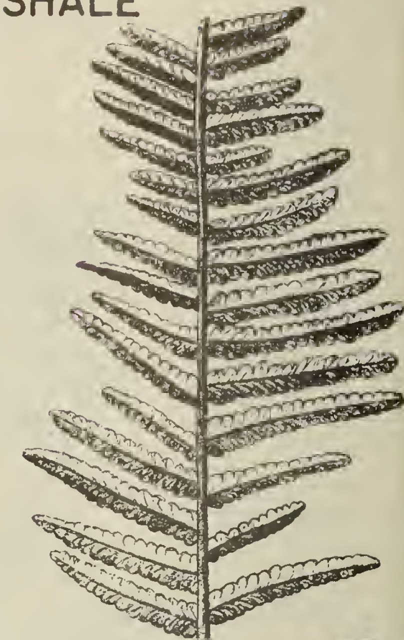

PELECYPODS
Nucula (Nuculopsis) girtyi 1x
Edmonia ovata 2x
Astartella concentrica 1x
Dunbarella knighti 1 1/2 x
Cardiomorpha missouriensis "Type A" 1x
Cardiomorpha missouriensis "Type B" 1 1/2 x
GASTROPODS
Euphemites carbonarius 1 1/2 x
Trepospira illinoisensis 1 1/2 x
Donaldina robusta 8x
Naticopsis (Jedria) ventricosa 1 1/2 x
Trepospira sphaerulata 1x
Knightites montfortianus 2x
Glabrocingulum (Glabrocingulum) grayvillense 3x

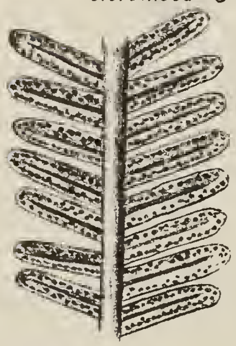
FOSSIL PLANTS, FRANCIS CREEK SHALE



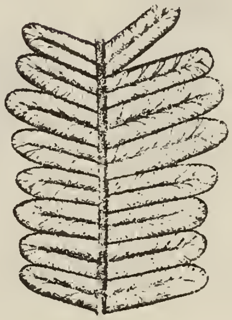
Asterotheca 5:1

Pecopteris 5:1

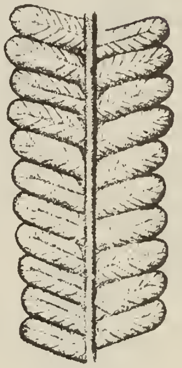




Asterotheca sp. 1:1



Pecopteris sp. 1:1

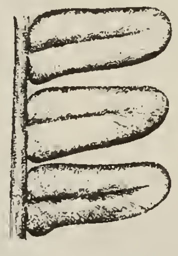


Pecopteris unita 1:1

Pecopteris sp. 1:1

Sphenopteris sp. 1:1

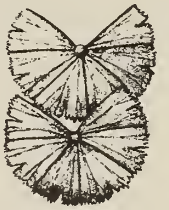
Neuropteris rarinervis 1:1



Neuropteris ovata 1:1

Sphenopteris sp. 1:1

Neuropteris scheuchzeri 1:1

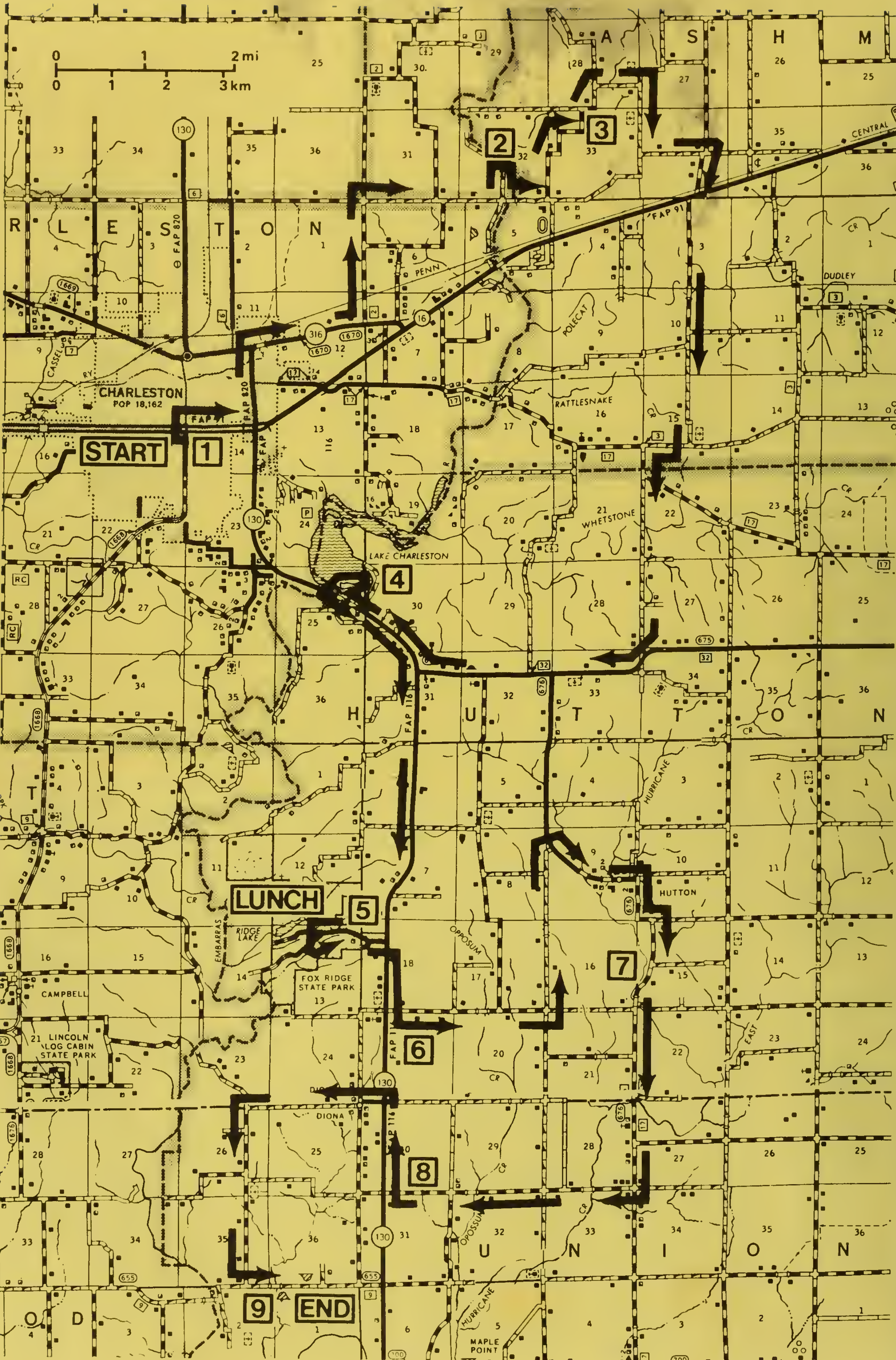


Sphenophyllum sp. 1:1

Alethopteris serlii 1:1

Mariopteris sp. 1:1

PLATE 3
(corrected)



0 1 2mi
0 1 2 3km
START
1
2
3
4
LUNCH
5
6
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8
9
END
CHARLESTON
POP 18,162
LAKE CHARLESTON
RIDGE LAKE
FOX RIDGE STATE PARK
LINCOLN LOG CABIN STATE PARK
CAMPBELL
DIONA
HUTTON
MAPLE POINT
DUDLEY
RATTLESNAKE
WHETSTONE
POLECAT
PENN
CASSEL
CENTRAL
EMBARRAS
OPOSSUM
HURRICANE
EAST
FAP 91
FAP 820
FAP 116
R L E S T O N
A S H M
H U T T O N
U N I O N
O D